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Standards of Performance for the control of emissions from phosphate rock plants are being proposed under the authority of Section 111 of the Clean Air Act. These standards would apply to new, modified, and reconstructed phosphate rock dryers, calciners, grinders, and ground rock handling systems, and would limit emissions of particulate matter by 85 to 98 percent below the levels permitted by current typical state regulations. This document contains background information, environmental and economic impact assessments, and the rationale for the proposed standards. Volume II, which will be published when the standards are promulgated, will contain a summary of the public comments on the proposed standard and EPA's responses. A discussion of any differences between the proposed and promulgated standards will also be included.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
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1. SUMMARY

1.1 PROPOSED STANDARDS

Standards of performance for phosphate rock plants are being proposed under the authority of Section 111 of the Clean Air Act. Accordingly, the aim of the proposed standards is to require the best demonstrated technology (considering cost and nonair quality health and environmental impact and energy requirements) for the control of particulate emissions be installed and properly operated at new, modified, and reconstructed phosphate rock plants. The proposed standard is based on information presented in this document and derived from 1) available technical literature on the phosphate rock industry and applicable emissions control technology, 2) technical studies performed for EPA by independent research organizations, 3) data obtained from the industry during visits to phosphate rock plants and communications with various representatives of the industry, 4) comments and suggestions solicited from experts, and 5) the results of emissions measurements conducted by EPA and the industry. In accordance with Section 117 of the Clean Air Act, proposal of the standards was preceded by consultation with appropriate advisory committees, independent experts, industry representatives, and Federal departments and agencies.

A summary of the proposed standards and monitoring requirements is presented in Table 1-1. The proposed standards limit particulate emissions from dryers, calciners, grinders, and phosphate rock handling/storage facilities. For each facility, the best system of continuous emission reduction, considering cost and nonair quality health and environmental impact and energy requirements, was determined to be the baghouse or the high energy scrubber. However,

Table 1-1. SUMMARY OF PROPOSED STANDARDS AND MONITORING REQUIREMENTS

Affected Facility	Emissions Standard		Opacity Standard	Monitoring Requirements
	kg/Mg[a]	lb/ton		
1. Dryer	0.02	0.04	0%	opacity[b]
2. Calciner	0.055	0.11	0%	opacity[b]
3. Grinder	0.006	0.012	0%	opacity[b]
4. Handling & Storage	--	--	0%	opacity[b]

a. The proposed standards are expressed in terms of the metric units kilogram per megagram of rock feed (kg/Mg).

b. If a scrubber is used to control emissions, monitoring requirements shall include the scrubber pressure drop and liquid supply pressure.

the high efficiency electrostatic precipitator (ESP) was judged to be equally as effective a particulate emissions reduction system as the baghouse or high energy scrubber. The proposed standards are, therefore, based on the use of any of the three alternative emissions reduction systems. Cost considerations would favor the use of the baghouse or high energy scrubber over the electrostatic precipitator, and the incremental nonair quality adverse impacts associated with the alternative controls would favor the use of the baghouse (especially for grinders and phosphate rock handling/storage systems) over the scrubber and ESP.

The proposed standards for phosphate rock dryers limit emissions to 0.02 kilogram of particulate matter per megagram of rock feed (0.04 lb/ton) and 0 percent opacity. These standards are based on EPA source tests at two representative phosphate rock plants processing Florida pebble rock, and related experience concerning the identified "best system of continuous emission reduction." The test data are summarized in Figures 8.4, 8.5 and 8.6. The results of the tests show that the dryer controlled by a venturi scrubber operating at a pressure drop of 18 inches of water will achieve an emissions level of about 0.019 kg/Mg, while the dryer employing an electrostatic precipitator and scrubber system for control achieved an emission level of 0.012 kg/Mg during tests conducted by the EPA. The level of control (99.2%) attained by the venturi scrubber at 18 inches of pressure drop is nearly equivalent to that which would be expected using the best system of emissions reduction (the baghouse or a high energy venturi scrubber operating at 25 inches of water pressure drop). Consequently, it is concluded that the emissions level of 0.02 kg/Mg reflects the control attainable by the best system of emissions reduction.

The proposed standards for phosphate rock calciners limit emissions to 0.055 kilogram of particulate matter per megagram of rock feed (0.11 lb/ton) and 0 percent opacity. These standards are based mainly on EPA source tests at two representative phosphate rock calciners processing western beneficiated and unbeneficiated phosphate rock. The test data are summarized in Appendix C. One of the calciners employed a high energy wet scrubber considered to be representative of the best system of emissions reduction. The other calciner employed a wet scrubber with collection efficiency somewhat less than that reflecting the best system of emissions reduction. For this calciner, the expected level of control which would be achieved by the best system of emissions reduction was estimated by adjusting emissions test data to reflect operation of the venturi scrubber at an elevated pressure drop of 27 inches of water. These adjusted emission levels, as well as those measured for the existing high energy scrubber, are consistent with the level of control being proposed as the limit of the standard.

The proposed standards for phosphate rock grinders limit emissions to 0.006 kg/Mg of rock feed (0.012 lb/ton) and 0 percent opacity. These standards are based on EPA source tests at four separate grinder facilities representing a wide range of exhaust air rates, grinder designs, capacities, and product feeds. Emissions from all the facilities were controlled by baghouses. The level of control reflected by the proposed emissions limit has been set slightly greater than the value attained by baghouses in the tests to account for potential inaccuracies in the feed rate data compiled during the source tests. However, the potential liberal level of the standard should not preclude installation of the best system of emissions reduction in new and modified facilities. Baghouses are the prevailing control approach now employed to meet existing standards far less stringent than the proposed standard. Moreover, the proposed emissions limit is lower than that which would be attained by any other control system economically comparable to the baghouse.

The proposed standard for ground phosphate rock material handling and storage systems limit emissions of particulate matter to 0 percent opacity from any point in the transfer system. The standard is based on EPA source tests at three separate rock transfer facilities utilizing pneumatic systems. Experience shows that no visible emissions occur from the enclosures when the process equipment is properly maintained. Because of the wide variation in handling and storage facilities, a visible emissions standard is the only standard appropriate for these facilities.

The proposed opacity standards help to assure that emission control systems are properly maintained and operated so as to comply with the mass emission standards on a continuous basis. The opacity standards have been proposed on the basis of tests performed at facilities representative of best emissions control technology currently employed by the industry. The test data are summarized in Appendix C.

1.2 ENVIRONMENTAL AND ECONOMIC IMPACT

Estimates of the relative beneficial and adverse impacts associated with the proposed standards and the various candidate emission control alternatives are presented in Table 1-2. The judgements presented in the matrix of Table 1-2 are based on the environmental impact analysis of Chapter 6 and the economic impact analysis of Chapter 7. A cross reference between the EPA guidelines for the preparation of Environmental Impact Statements and this document is included in Appendix B.

Table 1-2. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF PROPOSED STANDARDS FOR PHOSPHATE ROCK FACILITIES

Affected Facility	Control Alternative	Air Impact	Water Impact	Solid Waste Impact	Energy Impact	Radiation Impact	Economic Impact	Inflation Impact
Dryer	Baghouse	+3	+1	+1	-1	+1	-1	0
	High Energy Scrubber	+3	-1	-1	-2	-1	-1	0
	High Efficiency ESP	+3	-1[a]	-1[a]	0	-1[a]	-3	0
	Low Energy Scrubber (baseline control)	0	0	0	0	0	0	0
Calciner	Baghouse	+3	+1	-1	-1	+1	-1	0
	High Energy Scrubber	+3	-1	-1	-2	-1	-1	0
	High Efficiency ESP	+3	-1[a]	-1[a]	0	-1[a]	-3	0
	Low Energy Scrubber (baseline control)	0	0	0	0	0	0	0
Grinder	Baghouse (baseline control)	0	0	0	0	0	0	0
	High Energy Scrubber	0	-2	-2	-1	-2	-2	0
Rock Handling/ Storage Systems	Baghouse	0	0	0	0	0	0	0
	Scrubber	0	-2	-2	-1	-2	-2	0

Legend:
+ beneficial impact
- adverse impact
0 no impact

1 negligible impact
2 small impact
3 moderate impact
4 large impact

[a] This is for a wet ESP. If dry ESP is used, the impact is +1.

The impact of the standard is judged by comparing the consequences of imposing the standard to the consequences expected to result under current State implementation regulations. Accordingly, the matrix compares the impact of each candidate control capable of achieving the proposed standard with the prevailing controls (baseline controls) now being employed to meet typical State implementation regulations.

For both the phosphate rock dryer and calciner, the low energy wet scrubber is the baseline control system upon which the impacts associated with the other control alternatives are measured. Compliance with the proposed standard (by application of any of the three candidate control systems) will improve air quality significantly over that attained by the low energy scrubbers. Emissions from dryers would be reduced by approximately 85 percent below the levels required by a typical State standard, and emissions from calciners would be reduced by about 88 percent below the typical State requirements. The maximum 24-hour average ambient air concentration of particulate matter due to emissions from a typical dryer or calciner controlled to the level of the proposed standard would be about 88 $\mu g/m^3$ and 14 $\mu g/m^3$, respectively.

The secondary environmental impacts due to the proposed standards for dryers and calciners are expected to be minimal with two exceptions: 1) the economic impact incurred when high efficiency electrostatic precipitators are used to achieve the standard, and 2) the energy impact when high energy wet scrubbers are employed. Utilization of the electrostatic precipitator for control of dryer and calciner emissions would increase overall production costs (over costs to meet SIP regulations) by about 2.2 or 5.3 percent, respectively. Utilization of the high energy scrubber would increase total energy requirements of the dryer and calciner processes by about 8 percent. The magnitude of either of these impacts would not preclude the use of the associated control system. However, it is expected that the baghouse and the high energy scrubber would provide the most economical means of achieving the proposed levels of control for dryers and calciners, and the likelihood of operators installing electrostatic precipitators to comply with the NSPS appears remote. Installation and operation of baghouses for control of dryer or calciner emissions is expected to increase overall production costs at any given plant by about 0.1 and 0.3 percent, respectively. Similarly, the increase in production costs when high energy scrubbers are employed to meet the proposed standards for dryers and calciners would be about 0.4 and 1.2 percent, respectively.

The amount of water required for air pollution control of dryer and calciner emissions is small in comparison with the large volumes of process waters used for other purposes. The incremental increase (over the baseline control) of solid materials and radiochemical pollutants collected from wet control devices designed to attain the standard is negligible compared to the total amounts already collected by the baseline controls and still more inconsequential when compared to the total quantity of solid wastes produced in the mining and processing of phosphate rock.

For the phosphate rock grinder and rock transfer systems, the baghouse is the baseline control system upon which impacts associated with other control alternatives are assessed. The prevailing control practice in the industry is to employ baghouses to control grinding and transfer systems. Because the system of best emission reduction is currently utilized to meet

State implementation regulations, the more stringent emission limits of the proposed standard are not expected to result in significant impact. If alternative controls (other than the baseline control) are utilized (e.g., the wet scrubber) to meet the standards, only small secondary incremental impacts would be expected to occur. (See Table 1-2.)

1.3 ECONOMIC IMPACT ANALYSIS

Executive Order 12044, dated March 24, 1978, requires executive branch agencies to prepare regulatory analyses for regulations that may have major economic consequences. The screening criteria used by EPA to determine if a proposal requires a regulatory analysis under Executive Order 12044 are: 1) additional national annualized compliance costs, including capital charges, which total $100 million within any calendar year by the attainment date, if applicable, or within five years; and 2) a major increase in prices or production costs.

The impacts associated with the proposal of performance standards for phosphate rock plants do not exceed the EPA screening criteria. Therefore, promulgation of the proposed standard does not constitute a major action requiring preparation of an economic impact analysis under the Economic Impact Statement Program.

2. INTRODUCTION

Standards of performance are proposed following a detailed investigation of air pollution control methods available to the affected industry and the impact of their costs on the industry. This document summarizes the information obtained from such a study. Its purpose is to explain in detail the background and basis of the proposed standards and to facilitate analysis of the proposed standards by interested persons, including those who may not be familiar with the many technical aspects of the industry. To obtain additional copies of this document or the Federal Register notice of proposed standards, write to EPA Library (MD-35), Research Triangle Park, North Carolina 27711. Specify Phosphate Rock Plants - Background Information for Proposed Standards, document number EPA-450/3-79/017 when ordering.

2.1 AUTHORITY FOR THE STANDARDS.

Standards of performance for new stationary sources are established under section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, hereafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect, ". . . the degree of emission limitation achievable through the application of the best technological system of continuous emission reduction . . . the Administrator determines has been adequately demonstrated." In addition, for stationary sources whose emissions result from fossil fuel combustion, the standard must also include a percentage reduction in emissions. The Act also provide that the cost of achieving the necessary emission reduction, the nonair quality health and environmental impacts and the energy requirements all be taken into account in establishing standards of performance. The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments of the Act altered or added numerous provisions which apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources which have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

25 per cent of the listed categories by August 7, 1980
75 per cent of the listed categories by August 7, 1981
100 per cent of the listed categories by August 7, 1982

A governor of a State may apply to the Administrator to add a category which is not on the list or to revise a standard of performance.

2. EPA is required to review the standards of performance every four years, and if appropriate, revise them.

3. EPA is authorized to promulgate a design, equipment, work practice, or operational standard when an emission standard is not feasible.

4. The term "standards of performance" is redefined and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low-polluting or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under section 111 of the Act is extended to six months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal burning sources can adversely affect the coal market by driving up the price of low sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under section 116 of the Act to establish even more stringent emission limits than those established under section 111 or those necessary to attain or maintain the national ambient air quality standards (NAAQS) under section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area which falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term "best available control technology" (BACT), as defined in the Act, means " . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of 'best available control technology' result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to section 111 or 112 of this Act."

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(j) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling, and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require, or an equivalent reduction at lower economic, energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to public health, welfare or safety; (4) the governor of the State where the source is located consents; and that, (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to three years to meet the standards, with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Administrator to list categories of stationary sources which have not been listed before. The Administrator, ". . . shall include a category of sources in such list if in his judgment it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow while adhering to the schedule referred to earlier.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are emitted by stationary sources. Source categories which emit these pollutants were then evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might be required from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented, in a preselected future year, by standards of the source category. Sources for which new source performance standards were promulgated or are under developemnt during 1977 or earlier, were selected on these critieria.

The Act amendments of August, 1977, establish specific criteria to be used in determing priorities for all source categories not yet listed by EPA. These are

1) the quantity of air pollutant emissions which each such category will emit, or will be designed to emit;

2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and

3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

In some cases, it may not be feasible to immediately develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, determining the types of facilities within the source category to which the standards will apply must be decided. A source category may have several facilities that cause air pollution and emissions from some of these facilities may be insignificant or very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there be no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, and the nonair quality health and environmental impacts and energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for development of standards is to identify the best technological system of continuous emission reduction which has been adequately demonstrated. The legislative history of section 111 and various court decisions make clear that the Administrator's judgment of what is adequately demonstrated is not limited to systems that are in actual routine use. The search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience. In most cases, determination of the ". . . degree of emission reduction achievable . . ." is based on results of tests of emissions from well controlled existing sources. At times, this has required the investigation and measurement of emissions from control systems found in other industrialized countries that have developed more effective systems of control than those available in the United States.

Since the best demonstrated systems of emission reduction may not be in widespread use, the data base upon which standards are developed may be somewhat limited. Test data on existing well-controlled sources are obvious starting points in developing emission limits for new sources. However, since the control of existing sources generally represents retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered before a judgment can be made as to the level at which the emission standard should be set.

A process for the development of a standard has envolved which takes into account the following considerations.

1. Emissions from existing well-controlled sources as measured.

2. Data on emissions from such sources are assessed with consideration of such factors as: (a) how representative the tested source is in regard to feedstock, operation, size, age, etc.; (b) age and maintenance of the control equipment tested; (c) design uncertainties of control equipment being considered; and (d) the degree of uncertainty that new sources will be able to achieve similar levels of control.

3. Information from pilot and prototype installations, guarantees by vendors of control equipment, unconstructed but contracted projects, foreign technology, and published literature are also considered during the standard devlopment process. This is especially important for sources where "emerging" technology appears to be a significant alternative.

4. Where possible, standards are developed which permit the use of more than one control technique or licensed process.

5. Where possible, standards are developed to encourage or permit the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control.

6. In appropriate cases, standards are developed to permit the use of systems capable of controlling more than one pollutant. As an example, a scrubber can remove both gaseous and particulate emissions, but an electrostatic precipitator is specific to particulate matter.

7. Where appropriate, standards for visible emissions are developed in conjunction with concentration/mass emission standards. The opacity standard is established at a level that will require proper operation and maintenance of the emission control system installed to meet the concentration/mass standard on a day-to-day basis. In some cases, however, it is not possible to develop concentration/mass standards, such as with fugitive sources of emissions. In these cases, only opacity standards may be developed to limit emissions.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires, among other things, an economic impact assessment with respect to any standard of performance established under section 111 of the Act. The assessment is required to contain an analysis of:

(1) the costs of compliance with the regulation and standard including the extent to which the cost of compliance varies depending on the effective date of the standard or regulation and the development of less expensive or more efficient methods of compliance;

(2) the potential inflationary recessionary effects of the standard or regulation;

(3) the effects on competition of the standard or regulation with respect to small business;

(4) the effects of the standard or regulation on consumer cost, and,

(5) the effects of the standard or regulation on energy use.

Section 317 requires that the economic impact assessment be as extensive as practical, taking into account the time and resources available to EPA.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and by comparision with the control costs that would be incurred as a result of compliance with typical existing State control regulations. An incremental approach is taken since both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the impact upon the industry resulting from the cost differential that exists between a standard of performance and the typical State standard.

The costs for control of air pollutants are not the only costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absence of Federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry, as this factor also influences the ability of new plants to generate the capital required for installation of additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the Federal Courts of Appeals have held that environmental impact statements need not be prepared by the Agency for proposed actions under section 111 of the Clean Air Act. Essentially, the Federal Courts of Appeals have determined that ". . . the best system of emission reduction, . . . requires(s) the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry . . ." On this basis, therefore, the Courts ". . . established a narrow exemption from NEPA for EPA determination under section 111."

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969."

The Agency has concluded, however, that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, while not legally required to do so by section 102(2)(C) of NEPA, environmental impact statements will be prepared for various regulatory actions, including standards of performance developed under section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section is included in this document which is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are identified and discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the contruction or modification of which is commenced . . ." after the proposed standards are published. An existing source becomes a new source if the source is modified or is reconstructed. Both modification and reconstruction are defined in amendments to the general provisions of Subpart A of 40 CFG Part 60 which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416). Any physical or operational change to an existing facility which results in an increase in the emission rate of any pollutant for which a standard applies is considered a modification. Reconstruction, on the other hand, means the replacement of componenets of an existing facility to the extent that the fixed capital cost exceeds 50 percent of the cost of constructing a comparable entirely new source and that it be technically and economically feasible to meet the applicable standards. In such cases, reconstruction is equivalent to new construction.

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under section 111(d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e. a pollutant for which air quality criteria have not been issued under section 108 or which has not been listed as a hazardous pollutant under section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by an industry may improve with technological advances. Accordingly, section 111 of the Act provides that the Administrator ". . . shall, at least every four years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. PHOSPHATE ROCK PROCESSING INDUSTRY

3.1 GENERAL

The phosphate rock industry consists of mining and rock processing operations centered close to ore reserves.

Phosphate rock mines of significant commercial importance are located in Florida, North Carolina, Tennessee, Idaho, Wyoming, Utah, and Montana (Figure 3-1).[1] In 1975, 21 producers were spread over 36 locations and employed a total of about 12,000 people.[2] Table 3-1 presents the total domestic production and shipments for the years from 1965 to 1977. Future production is expected to increase to an annual rate of five percent.[5]

Nearly three-quarters of the domestic production capacity is located in Florida. In 1976, Florida and North Carolina produced 41.3 million tons, accounting for more than 84 percent of the total domestic production.[6]

Phosphate rock is used primarily to produce phosphatic fertilizers. About 20 percent of the rock is converted to other products, such as elemental phosphorus and defluorinated animal-feed supplements. Thirty percent is exported.[7]

The ingredient of the rock that is of economic interest is tricalcium phosphate, $Ca_3(PO_4)_2$, also known in the industry as bone phosphate of lime (BPL) because the first commercial source of this chemical was charred animal bones. The rock is usually graded on the basis of its BPL content, e.g., 68 BPL rock contains 68 percent by weight of tricalcium phosphate. The final product contains roughly 68 to 74 percent BPL.[8]

Chemically, phosphate rock may be considered to contain a substituted fluorapatite. The basic fluorapatite structure is represented as

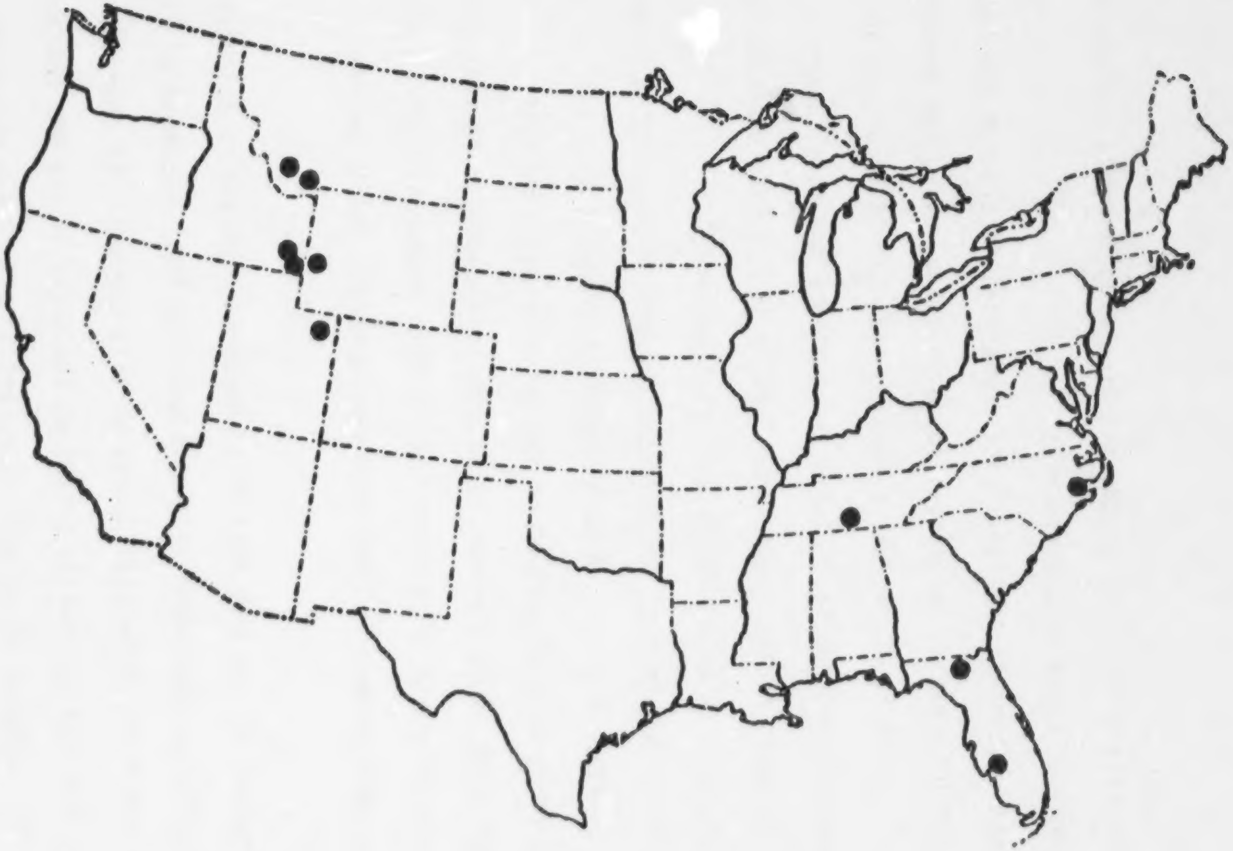

Figure 3 -1. Geographical location of phosphate rock operations.[4]

Table 3-1. PRODUCTION AND SHIPMENTS OF PHOSPHATE ROCK[3,4]

Year	Production (10^3 tons)	Shipments (10^3 tons)
1965	29,482	29,039
1966	39,044	36,443
1967	39,700	37,835
1968	41,251	37,319
1969	37,725	36,730
1970	38,739	38,765
1971	38,886	40,291
1972	40,831	43,755
1973	42,137	45,043
1974	45,686	48,435
1975	48,816	48,439
1976	48,659	43,230
1977	51,266	51,383

$3Ca_3(PO_4)_2 \cdot Ca_2F$.[9] Nearly all phosphate ores contain a modified form of this structure in which some of the phosphate is replaced by fluoride and carbonate.[10] The total fluoride content of typical phosphate rock is approximately 4 to 5 percent by weight, expressed as fluorine.[11]

Commercial phosphate rock contains 30 to 38 percent P_2O_5 plus a variety of impurities such as iron, aluminum, magnesium, silica, carbon dioxide, sodium, potassium, and sulfates.[12]

3.2 PROCESSING METHODS - GENERAL

There are two major characteristics of phosphate rock which influence the way it is mined and processed--hardness and organic content. Generalized flow diagrams for phosphate rock mining and processing operations in Florida, Tennessee, and the Western states are presented in Figures 3-2, 3-3, and 3-4, respectively.

Only phosphate rock operations associated with fertilizer manufacture were investigated for development of standards of performance. The basis for their selection and for the omission of other phosphate operations such as elemental phosphorus, thermal defluorination, and nodulizing, is presented in Chapter 8.

3.2.1 Mining and Beneficiation

Hard rock is found in the Western states, with hardness generally decreasing the further north it is found. Conventional earth moving equipment is used to remove the first five to fifty feet of earth, called overburden, thus exposing the layer of phosphate rock. The rock is then removed from the deposit using a number of techniques, ranging from dynamite blasting for the hard rocks found in Utah, to using a "ripper" (a toothed implement used for gouging and breaking the rock from the surface) for the softer rocks. Two small underground mines are also operated in Montana.

Western rock is usually hauled by truck to the rock processing plant. The first step in processing the rock is to separate it from impurities, a process called beneficiation. The sequence of steps comprising beneficiation at plants mining Western hard-rock ores differs from plant to plant depending

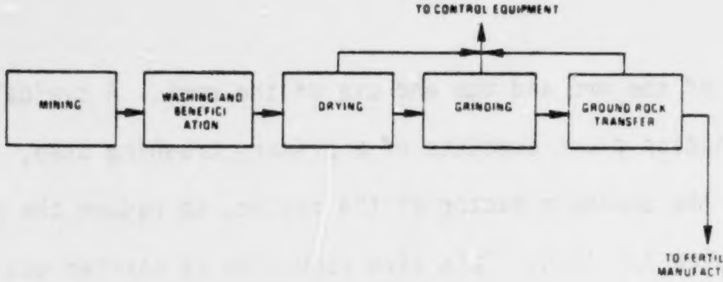
TO CONTROL EQUIPMENT
MINING
WASHING AND BENEFICIATION
DRYING
GRINDING
GROUND ROCK TRANSFER
TO FERTILIZER MANUFACTURING

Figure 3-2. Generalized flow scheme for Florida operations.

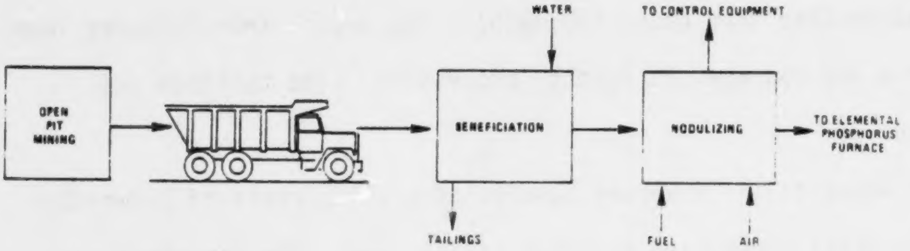
WATER
TO CONTROL EQUIPMENT
OPEN PIT MINING
BENEFICIATION
NODULIZING
TO ELEMENTAL PHOSPHORUS FURNACE
TAILINGS
FUEL
AIR

Figure 3-3. Generalized flow scheme for Tennessee phosphate rock.

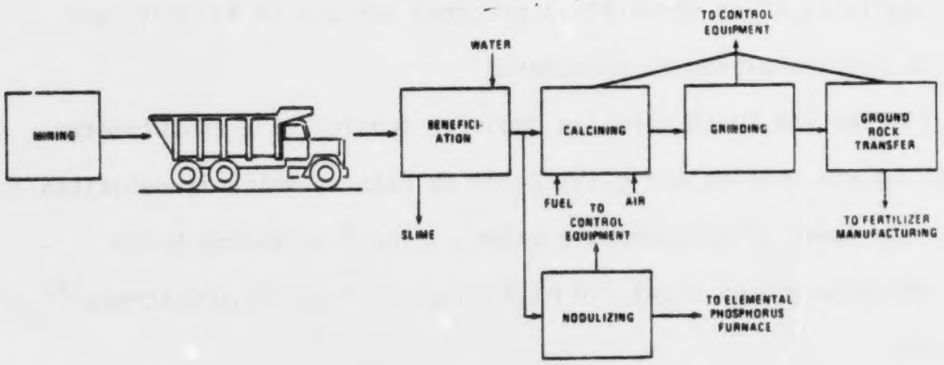
TO CONTROL EQUIPMENT
WATER
MINING
BENEFICIATION
CALCINING
GRINDING
GROUND ROCK TRANSFER
FUEL
TO CONTROL EQUIPMENT
AIR
SLIME
TO FERTILIZER MANUFACTURING
NODULIZING
TO ELEMENTAL PHOSPHORUS FURNACE

Figure 3-4. Generalized flow scheme for western phosphate rock.

on the hardness of the ore and the end use of the rock. A typical Western beneficiation plant consists of a primary crushing step, particularly in the southern sector of the region, to reduce the size of the ore to below 1/4 inch. This size reduction is carried out in several steps, the last of which is a slurry-grinding process which uses a wet rod mill to reduce the ore to particles about the size of beach sand. The slurry is then size-classified in hydrocyclones, using centrifugal force to separate product-size material from the tailings (clay and sand particles smaller than about 100 mesh). The ore is then filtered from the slurry and conveyed to further processing. The tailings are discarded.

The deposits in Tennessee consist of small pockets of brownish phosphate sands surrounded by brown silica sand. The phosphate sand is mined using draglines and small power shovels, then hauled by truck or rail to the processing plants. A typical Tennessee beneficiation unit consists of a unit called a log-washer, in which the ore is slurried with water and any large agglomerated masses are broken up, followed by size-classification using hydrocycloning. The product-size fraction is then sent to nodulizing kilns where it is prepared for use in electric arc furnaces to produce elemental phosphorus.

The Florida and North Carolina deposits consist of a consolidated mass of phosphate pebbles and clays known as matrix, which is deposited in a discrete layer of considerable extent. The Florida and North Carolina deposits occupy about 1.8 million acres[13] and 50,000 acres,[14] respectively.

Mining in Florida and North Carolina is conducted by stripping overburden from the matrix deposits and removing the matrix layer by use of large electrically driven draglines. Since the phosphate rock normally occurs below the water table, large pumps are used to keep the water out of the area being mined. Even so, the rock contains from 10 to 25 percent moisture as it comes from the ground. This high moisture content precludes any potential for particulate emissions during mining. Once mined, the matrix layer is dropped into sumps, slurried with water, and pumped to beneficiation plants. A typical Florida beneficiation unit involves a preliminary wet screening to separate a fraction called pebble rock, which is smaller than 1/4 inch and larger than 14 mesh, from the balance of the ore. The pebble product is then sent to the rock dryer. The North Carolina ore does not contain pebble rock. In North Carolina, the ore fraction larger than 1/4 inch is sent to a hammer mill and then recycled to the screens. In both Florida and North Carolina benefication processes, the ore fraction smaller than 14 mesh is slurried and treated by two-stage flotation, which uses hydrophilic or hydrophobic chemical reagents in conjunction with aeration to selectively separate suspended particles. No air pollutants are generated during either the mining or beneficiation processes except at a few plants which mine the hard rock in the southern part of the Western reserves. Because of the dry climate in that area, dust similar to that generated in rock quarrying operations is produced during mining and hauling of the rock.

Ore leaving the beneficiation plants must be either dried, calcined, or nodulized before it can be further processed. The particular route taken depends on its organic content and the ultimate product for which it is destined. Since Florida rock is relatively free of organics, it is dried by simply heating to about 250°F to drive off free water. Rocks mined from other reserves in the nation, however, contain organics and must be heated to 1400° to 1600°F. If not removed, the organics cause a slime which hinders filtration during the manufacture of wet-process phosphoric acid, the starting material for phosphate fertilizer. During nodulization, the ore is heated to 2200° to 2600°F. The nodulizing process not only drives off water, carbon dioxide, and organic matter, but also causes the ore to fuse into larger lumps suitable for feed to the electric arc furnace used in the manufacture of elemental phosphorus. Only the Tennessee ore and some Western ores are nodulized.

3.2.2. Drying

Phosphate ores are dried in direct-fired dryers, ie., the combustion products contact the ore directly. Most dryers are fired with either natural gas, No. 2 or No. 6 fuel oil, and many are equipped to burn more than one type of fuel. Through the late sixties and early seventies, there was a trend toward fuel oil, usually No. 6. Both rotary and fluidized-bed units are employed, with the rotary the more common. Figures 3-5 and 3-6 present typical schematics of the two types of dryers. Ore is about 10 to 15 percent moisture by weight when fed to the dryer. It is discharged when it reaches between 1 and 3 percent moisture, the percentage being determined by the ultimate use of the ore. As shown in Table 3-2, capacities of dryers range from 5 to 350 tons per hour (tph), with 200 tph a representative average. The newer installations favor the larger capacities. Typical air volumes used by the industry range from 20,000 dry standard cubic ft per minute (dscfm) for a 65 tph unit to 120,000 dscfm for a 350 tph unit. A typical dryer processing 250 tph of rock will discharge between 70,000 and 100,000 dscfm of gas. Conservative operators minimize air usage to decrease fuel consumption and to reduce the size and cost of the air pollution control device.

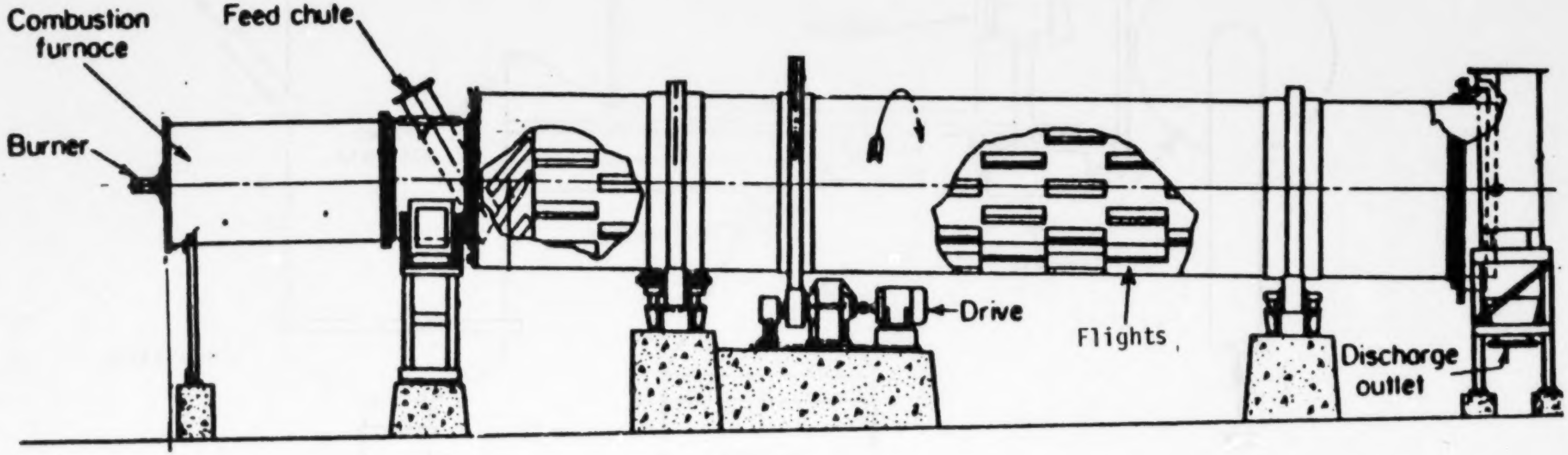
Combustion furnoce
Burner
Feed chute
Drive
Flights
Discharge outlet

Figure 3-5. Direct Fired, Cocurrent, Rotary Dryer

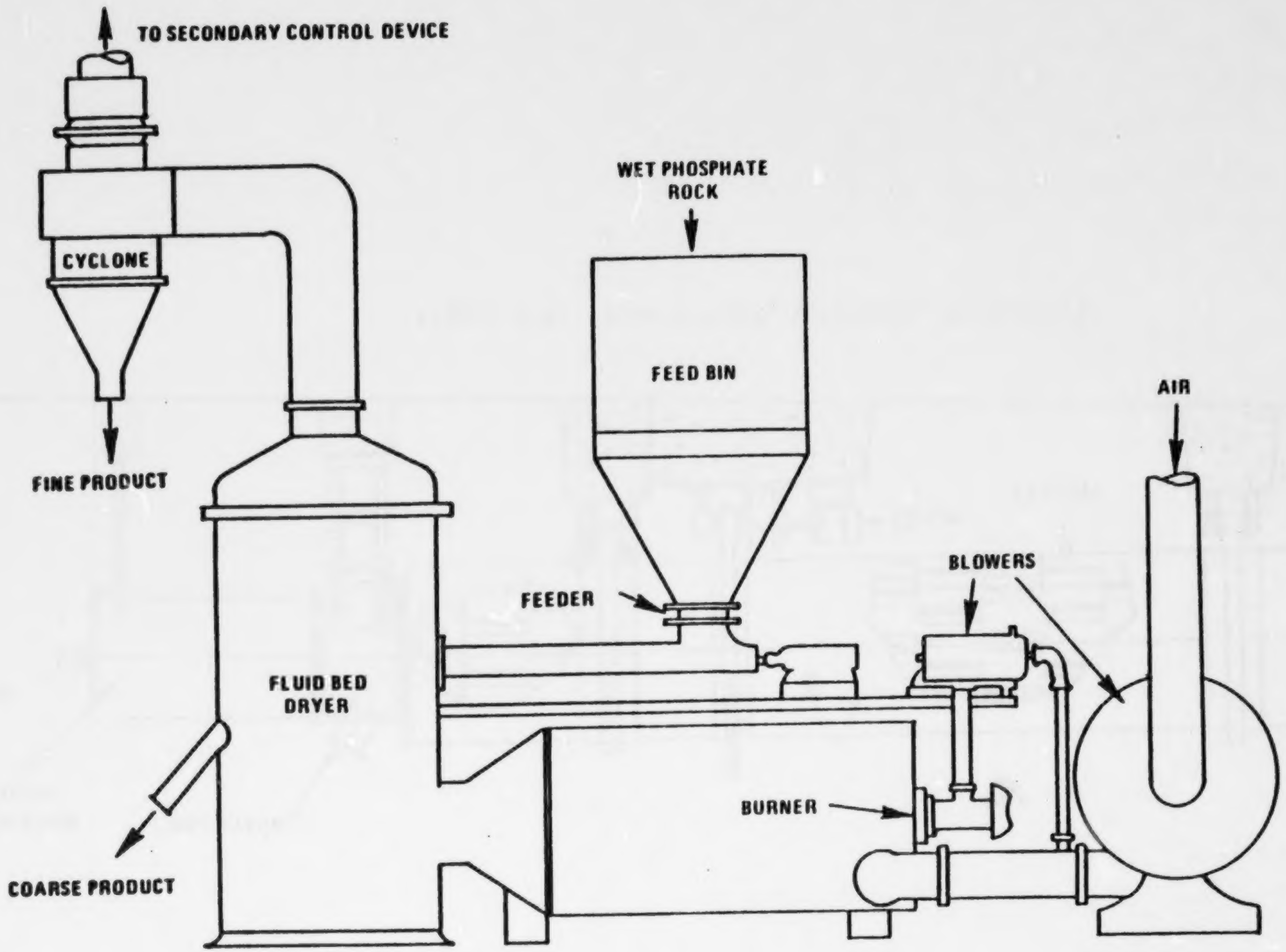
TO SECONDARY CONTROL DEVICE
CYCLONE
FINE PRODUCT
WET PHOSPHATE ROCK
FEED BIN
AIR
FEEDER
BLOWERS
FLUID BED DRYER
BURNER
COARSE PRODUCT

Figure 3-6. Fluid Bed Dryer.

Table 3-2. CAPACITIES AND GAS FLOW RATES FOR PHOSPHATE ROCK DRYERS[15]

Company	Location	Product Rate Tons/hr	Type of Facility	Stack Gas Flow Rate scfmX10^{-3}
Agrico Chemical	Pierce, Fla.	1,000	NR	800
Beker Industries	Conda, Idago	63	Fluid Bed	27
Borden Chemical	Plant City, Fla.	150	Rotary	52
Brewster Phosphates	Bradley, Fla.	315[a]	NR	145[a]
Conserv, Inc.	Nichols, Fla.	110	NR	27
Freeport Chemicals	Uncle Same, La.	200	Fluid Bed	NR
		200	Fluid Bed	NR
Gardinier, Inc.	Ft. Meade, Fla.	196	NR	77
W. R. Grace & Co.	Bartow, Fla.	330	Rotary)	130[a]
		165	Fluid Bed	
Hooker Chemical	Columbia, Tenn.	21	Rotary[b]	18
IMC Corporation	Noralyn, Fla.	550[a]	NR)	155[a]
			NR	
IMC Corporation	Kingsford, Fla.	333	Fluid Bed	70
Mobil Chemical	Nichols, Fla.	350	Rotary	78
		350	Rotary	78
Occidental Chemical	White Springs, Fla.	242	Fluid Bed	93
Rocky Mtn. Phosphates	Garrison, Montana	5	Rotary[c]	NR
J. R. Simplot	Conda, Idaho	150	Rotary[d]	22
Stauffer Chemical	Leefe, Wyoming	55	Rotary	15
Stauffer Chemical	Vernal, Utah	26	Rotary	10
		26	Rotary	10
Swift Chemical	Bartow, Fla.	178	Rotary	56
		265	Fluid Bed	76
Texasgulf, Inc.	Aurora, N.C.	233	Fluid Bed	NR
USS Agri-Chem	Ft. Meade, Fla	187	Rotary	NR

[a] Total for two dryers.

[b] This dryer operates at 400°F (exit gas temperature).

[c] This dryer operates at 250°-300°F (exit gas temperature).

[d] This dryer operates at 300°F (exit gas temperature).

Emissions from dryers range from 0.5 to 5 grains per dry standard cubic foot (gr/dscf), or about 400 to 4000 pounds per hour (lb/hr), for a typical 250 tph dryer. There are no significant differences in the gas volumes or emissions from fluid bed or rotary dryers.

Process variables which affect emissions from a phosphate rock dryer include the type of rock being processed (a factor only at Florida plants), fuel type, air flow rate, product moisture content in the case of a rotary dryer, and speed of rotation. A unique situation regarding rock types in the Florida industry deserves some comment. The pebble rock described earlier receives much less washing than does the concentrate rock from the flotation processes, and, therefore, has a higher clay content. As a result uncontrolled emissions from drying pebble rock are substantially higher than when drying ore from the flotation process.[16,17,18]

3.2.3. Calcining

The most common type of calciner is the fluidized-bed unit (illustrated in Figure 3-7), but rotary calciners are also used. Calciners differ from dryers in that their much higher temperatures require refractory linings. Also, as shown in Figure 3-6, the fluidized-bed dryer has an external combustion chamber with the flue gases passing through the dryer, whereas the calciner

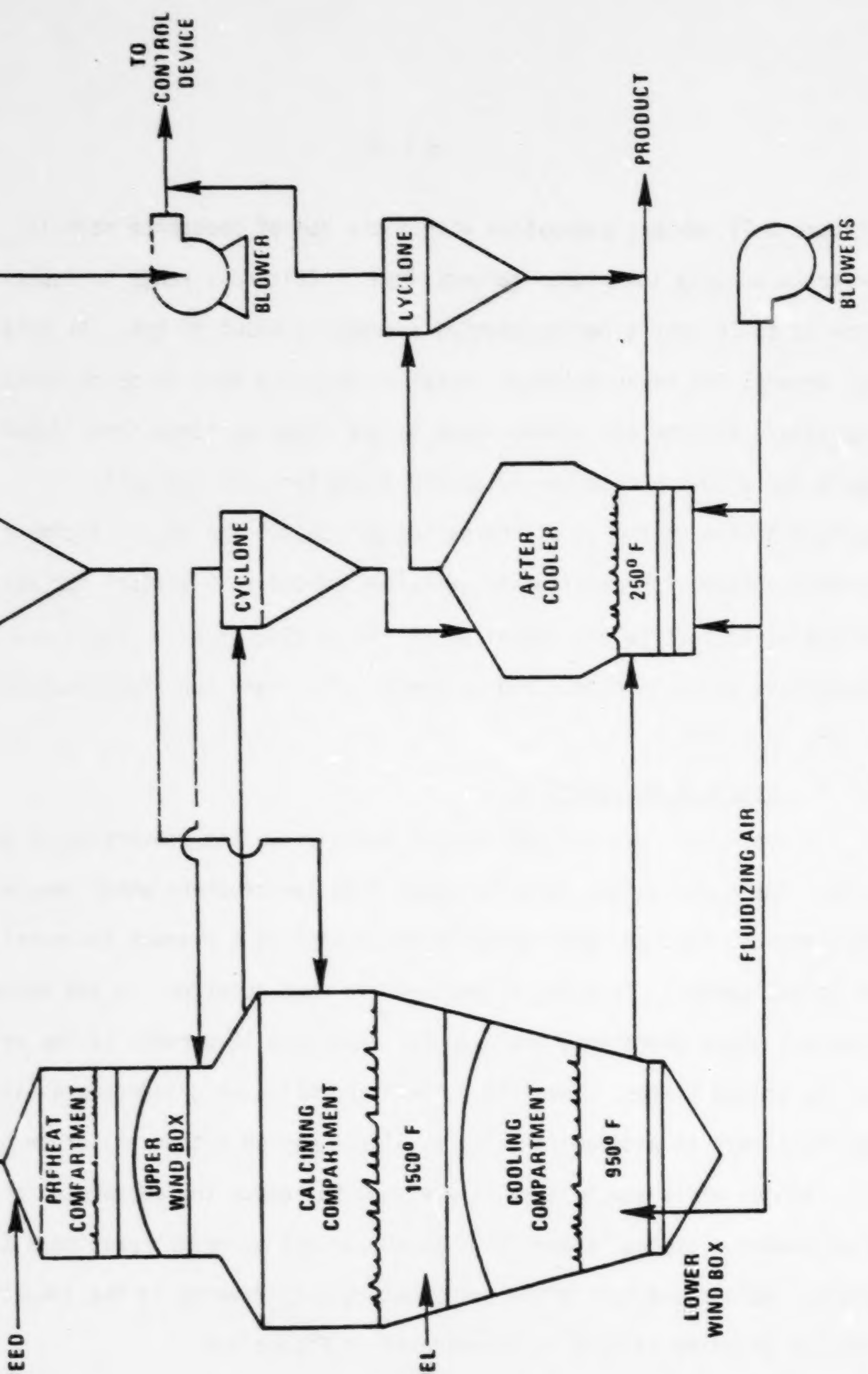
FEED
PREHEAT COMPARTMENT
UPPER WIND BOX
CALCINING COMPARTMENT
1500° F
FUEL
COOLING COMPARTMENT
950° F
LOWER WIND BOX
FLUIDIZING AIR
CYCLONE
CYCLONE
AFTER COOLER
250° F
CYCLONE
BLOWER
TO CONTROL DEVICE
PRODUCT
BLOWERS

Figure 3-7. Fluid bed calciner

(Figure 3-7) employs combustion within the bed of phosphate rock in order to achieve the higher temperatures. Calciners range in capacity from 20 to 70 tph; a representative average is about 50 tph. As noted for dryers, the newer calciner installations also tend to be of larger capacity. Average air volumes used by the industry range from 17,000 dscfm for a 20-tph calciner to 50,000 dscfm for a 70-tph unit. A typical 50-tph unit will discharge between 30,000 and 60,000 dscfm of exhaust volume with particulate emissions of 0.5 to 5 gr/dscf for total uncontrolled particulate emissions of 250 to 2500 lb/hr. Table 3-3 summarizes production rate and volumetric flow rate for fluid bed and rotary calciners.

3.2.4. Crushing and Grinding

Crushing and grinding are widely employed in the processing of phosphate rock. These operations range in scope from jaw crushers which reduce 12-inch hard rock to fine pulverizing mills which produce a product the consistency of talcum powder. Crushing is employed in some locations in the Western field; however, these operations are used for less than 12 percent of the rock mined in the United States. The fine pulverizing mills or grinders are used by all manufacturers to produce fertilizer. These may be either roller or ball mills,

Roller mills and ball mills are used to reduce the phosphate rock to a fine powder - typically specified as 60 percent by weight passing a 200-mesh sieve. Roller and ball mills are about equally favored in the industry. A typical grinding circuit is illustrated in Figure 3-8.

Table 3-3. CAPACITIES AND GAS FLOW RATES FOR PHOSPHATE ROCK CALCINERS[15]

Company	Location	Production Rate Tons/hr	Type of Calciner	Stack Gas Flow Rate scfmX10^{-3}
Beker Industries	Conda, Idaho	70	Fluid Bed	34
		70	Fluid Bed	40
Mobil Chemical	Nichols, Fla.	50	Rotary	55
J. R. Simplot	Pocatello, Idaho	35	Fluid Bed	25
		41	Fluid Bed	28
		55	Fluid Bed	58
Stauffer Chemical	Leefe, Wyoming	20	Fluid Bed	17
		20	Fluid Bed	17
		30	Fluid Bed	29
Texasgulf, Inc.	Aurora, N. C.	60	Fluid Bed	53
		60	Fluid Bed	53
		60	Fluid Bed	53
		60	Fluid Bed	53

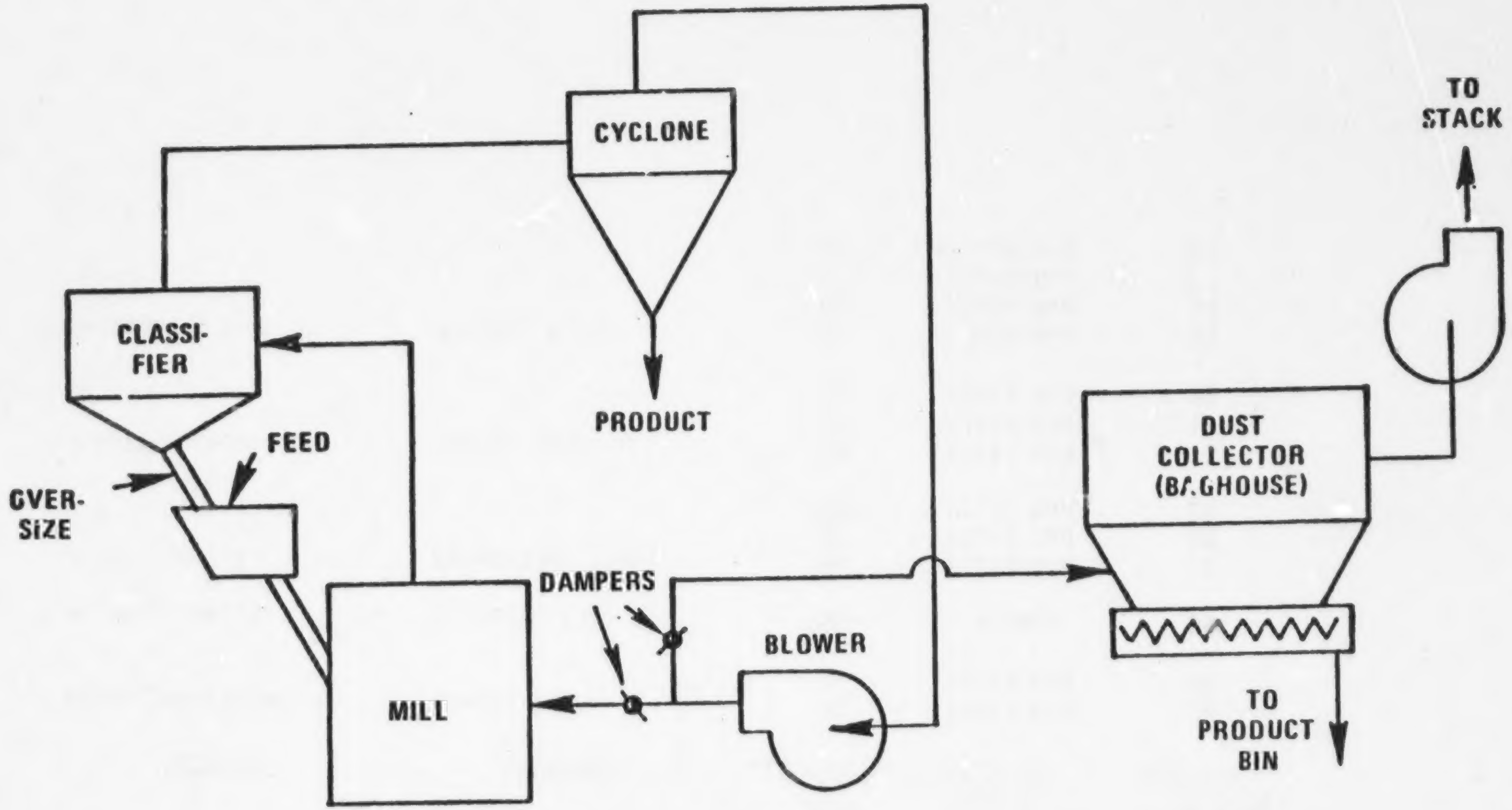
CYCLONE
CLASSIFIER
PRODUCT
FEED
OVERSIZE
DAMPERS
BLOWER
MILL
DUST COLLECTOR (BAGHOUSE)
TO STACK
TO PRODUCT BIN

Figure 3-8. Typical grinding circuit

The roller mill is composed of hardened steel rollers which rotate against the inside of a steel ring, as shown in Figure 3-9. Ore is fed into the mill housing by a rotary valve which prevents the escape of air into the feed system. The rock is scooped up from the floor of the housing by plows and directed into the path of the rollers, where it is ground between the rollers and the steel ring. Ground rock is swept from the mill by a circulating airstream. Some product size classification is provided by the "revolving whizzers" at the top of the housing. The average particle size leaving the mill can be controlled by varying the speed of revolution of the whizzers. Further size segregation is provided by the air classifier which separates oversize particles from product size particles and recycles the oversize portion to the mill. The product is separated from the carrying air stream by a cyclone and conveyed to ground-rock storage. The air stream is returned to the mill in a closed loop.

The ball mill is basically a drum revolving about an axis slightly inclined to the horizontal (Figure 3-10). The drum contains a large number of steel balls about 1 inch in diameter. Rock is charged into the mill through a rotary valve, ground by attrition with the balls, and swept from the mill by a circulating air stream as described above for roller mills.

Roller and ball mills are operated slightly below atmospheric pressure to avoid fugitive discharge of rock dust into the air. As a result, there is infiltration of atmospheric air into the circulating streams. This tramp air is discharged from the circuit through a dust collector to the atmosphere. Mill capacities range from 15 tph of phosphate rock for a smaller roller mill to about 260 tph for a large ball mill. Generally speaking, roller mills are

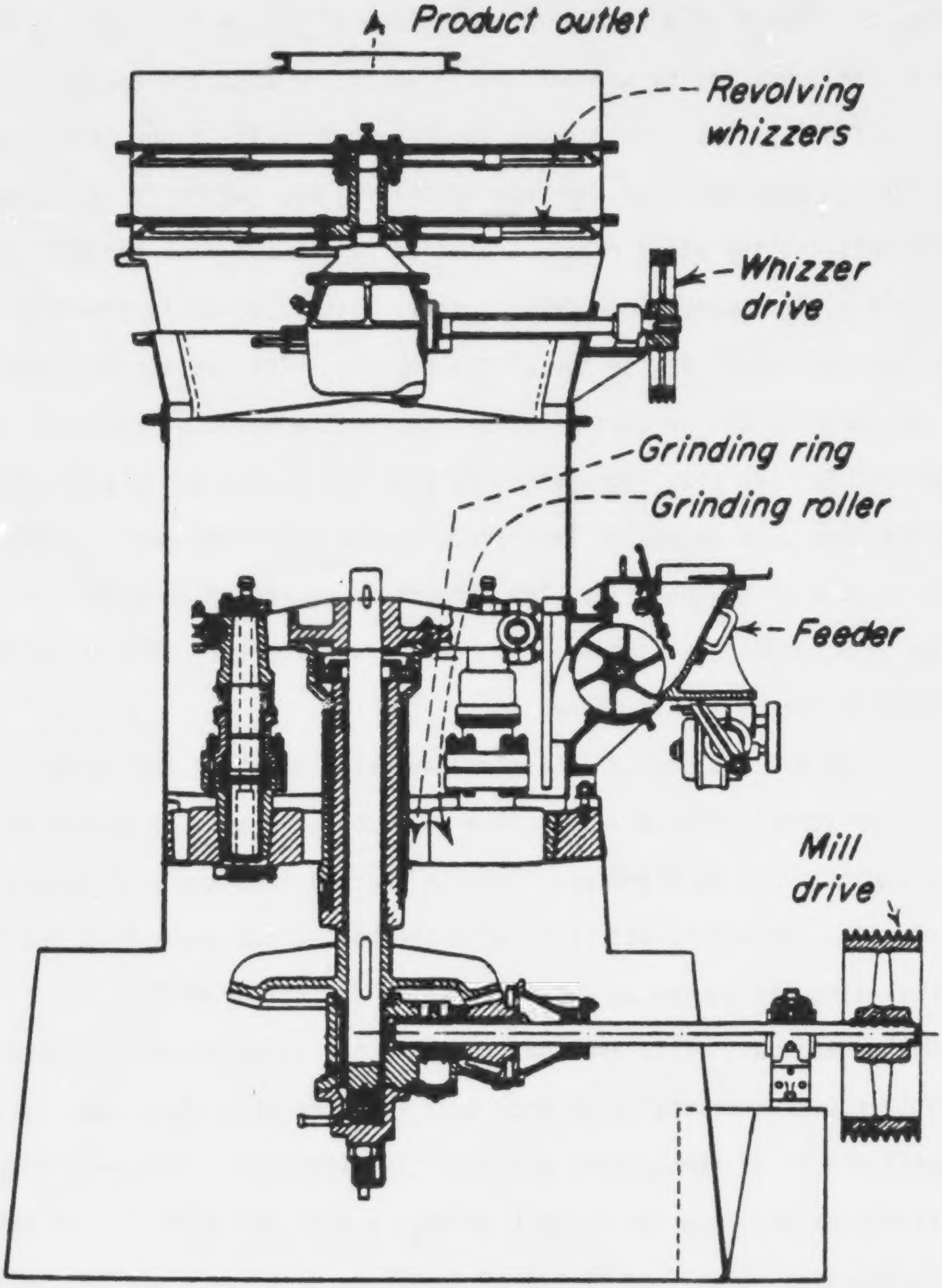
Product outlet
Revolving whizzers
Whizzer drive
Grinding ring
Grinding roller
Feeder
Mill drive

Figure 3-9. Roller Mill

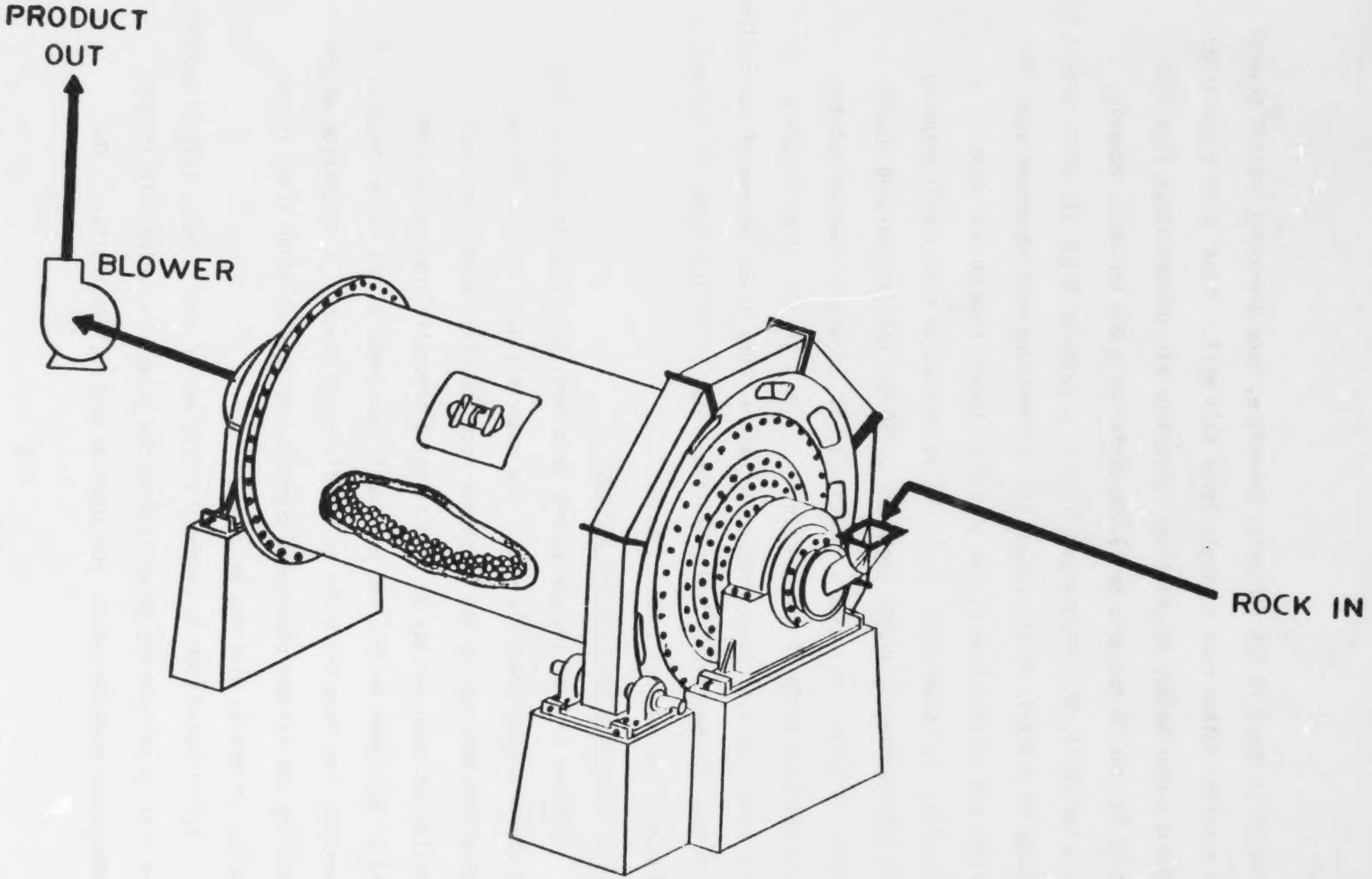
PRODUCT
OUT
BLOWER
ROCK IN

Figure 3-10. Rotary Ball Mill

limited to about 75 tph per unit; therefore, many operators install several in parallel rather than a single large ball mill. There is no clear trend toward either method of grinding. Discharge air volumes range from 1100 dscfm for the 15 tph unit to 19,000 dscfm for a 260 tph unit; however, as noted above, this discharge stream is a purge of tramp air which enters the system as a result of the vacuum and is therefore more dependent upon the design and construction of the grinding circuit than on the capacity of the mill. For example, it would not be unusual to find a mill grinding 150 tph discharging 19,000 dscfm nor a 250-tph unit discharging 10,000 dscfm. A typical mill has a capacity of 50 tph and discharges between 3500 and 5500 dscfm of air containing 0.5 to 5 gr/dscf of particulate. At this rate, the typical grinder could emit as much as 237 pounds of particulate each hour of operation. Table 3-4 summarizes production rate and volumetric flow rate for several types of mills.

3.2.5 Materials Handling and Storage

Between each of the operations described, provision is usually made to convey and/or store the rock. The materials handling and storage operations employed by the phosphate rock industry range from truck hauling and open storage to sophisticated pneumatic transfer systems and silos. Some mention has previously been made of the normal methods of conveying ore from the mines to beneficiation plants. A discussion of the handling and storage procedures commonly employed at other steps in the various processes will now be given.

Beneficiated rock is commonly stored wet in open piles. Several methods are used to reclaim the material from the piles, including skip loaders, underground conveyor belts, and above-ground reclaim trolleys. The

Table 3-4. CAPACITIES AND GAS FLOW RATES FOR PHOSPHATE ROCK GRINDERS[15]

Company	Location	Production Rate Tons/hr[a]	Number Of Mills	Type of Mill	Stack Gas Flow Rate[a] scfmX10^{-3}
Agrico Chemical	Pierce, Florida	173	6	Roller	20.4
Beker Industries	Conda, Idaho	60	1	Ball	3.8
		75	2	Ball	
Brewster Phosphates	Bradley, Florida	NR	2	Roller	7.1
Farmland Industries	Bartow, Florida	110	1	Ball	14.4
Freeport Chemicals	Uncle Sam, Louisiana	400	2	Ball	NR
Gardinier, Inc.	Tampa, Florida	235	1	Roller	9.6
			5	Roller & Ball	32.3
W. R. Grace and Co.	Bartow, Florida	45	3	Roller	16.3
		155	2	Ball	12.2
IMC Corporation	Noralyn, Florida	240	7	Roller & Ball	40.0
IMC Corporation	Kingsford, Florida	110	3	Roller	21.0
Mobil Chemical	Nichols, Florida	209	4	Roller	8.0
Occidental Chemical	White Springs, Fla.	124	1	Ball	13.6
Royster Company	Mulberry, Florida	65	2	Roller & Bowl	6.3
J. R. Simplott	Pocatello, Idaho	100	6	Roller	34.0
Stauffer Chemical	Leefe, Wyoming	40	3	Roller	NR
Swift Chemical	Bartow, Florida	45	3	Roller	6.0
Texasgulf, Inc.	Aurora, N. C.	150	2	Ball	24.0
USS Agri-Chem	Bartow, Florida	45	3	Roller	9.1
USS Agri-Chem	Ft. Meade, Florida	75	4	Roller	9.8

[a] Total for all mills

reclaimed ore is normally conveyed to the next processing step, whether drying, calcining, or nodulizing, by either open or weather-protected conveyor belts.

Rock discharged from the rock dryers or calciners is usually conveyed to storage silos on weather-protected conveyors. From the silos it is either transported in rail cars and trucks to consumers, or conveyed to grinding mills which prepare the rock for feed to fertilizer plants.

Ground rock is usually conveyed in some type of totally enclosed screw conveyor, the dust pump, or the air slide system. The screw conveyor consists of a long screw enclosed in a tube or covered trough, and is driven at one end. Ground rock fed into one end of the tube is carried along the flights of the screw and discharged at the opposite end. The dust pump system employs an aerated bin to generate a continuous stream of fluidized rock. The rock dust is then blown from the ground-rock surge bin to the receiving units through pipelines. Provision must be made at the discharge end to vent the conveying airstream. The air slide, illustrated in Figure 3-11, is composed of a rectangular duct separated into upper and lower segments by porous tile. The duct is inclined downward from the feed end to the discharge. Rock dust is fed into the upper segment of the duct, and air is blown at the low pressure into the lower segment. The air diffuses upward through the porous tile into the rock dust, assisting rock flow by gravity down the incline to the discharge end. Provision must be made to inject air at intervals throughout the length of a long conveyor and to purge the excess air from the upper segment.

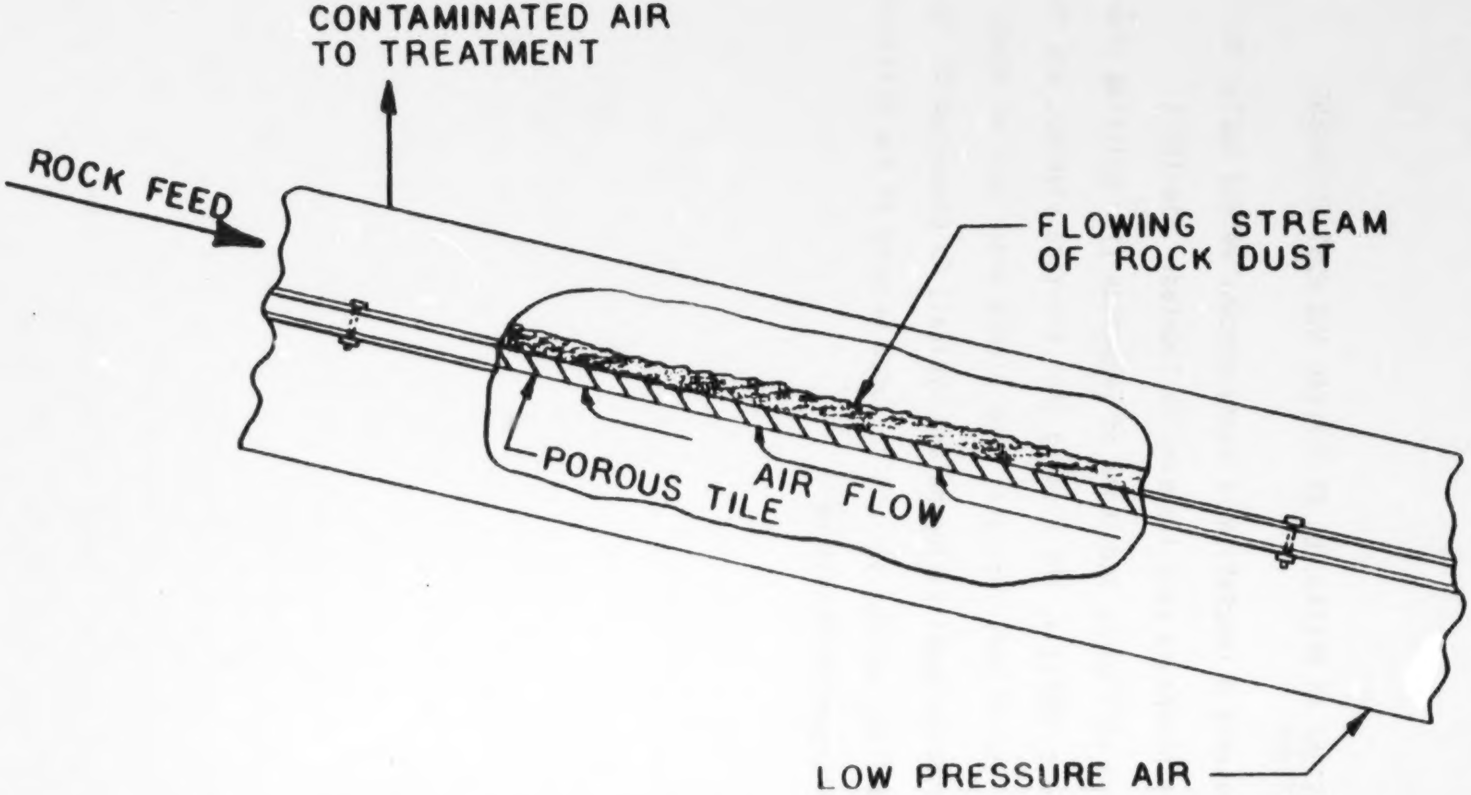
CONTAMINATED AIR
TO TREATMENT
ROCK FEED
FLOWING STREAM
OF ROCK DUST
POROUS TILE
AIR FLOW
LOW PRESSURE AIR

Figure 3-11. Typical Air Slide Conveyor

3.3. PROCESS EMISSIONS AS RESTRICTED BY TYPICAL AND MOST-STRINGENT STATE REGULATIONS

Table 3-5 presents a tabulation of state process weight tables for states in which the phosphate rock industry is located. Florida's limitations are most stringent, and those of Tennessee (for existing plants), North Carolina, Idaho, Montana, and Wyoming (for existing plants), are the typical. A comparison of emission rates from plants under each of these two levels of limitation (most stringent and typical) is presented in Table 3-6. Materials handling systems are not included because of the difficulty in determining a representative system.

Table 3-5. PROCESS WEIGHT TABLE OF PARTICULATE EMISSIONS LIMITATIONS[19]
(lb/hr)

	Hourly Production Rate Tons Per Hour							
	2.5	5	10	20	30	60	100	500
Florida	6.34	9.73	14.99	--	29.60	33.28	36.11	46.72
Tennessee[a]	6.34	9.70	15.00	23.00	29.60	33.30	36.10	46.70
North Carolina	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Idaho	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Montana	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Wyoming[a]	6.34	9.73	14.99	--	29.60	33.28	36.11	46.72
Utah		Required 85 percent control of particulate emissions						

[a] Applies to new sources only. Existing sources -- same as N. C., Idaho, and Montana.

Table 3-6. COMPARISON OF PARTICULATE EMISSIONS FROM PHOSPHATE ROCK PLANTS WHEN CONTROLLED BY TYPICAL AND MOST STRINGENT STATE REGULATIONS

Operation	Typical Production Rate	Emissions Under Typical State Control		Emissions Under Most Stringent State Control	
Units	tph	lb/hr	gr/dscf*	lb/hr	gr/dscf*
Drying	250	65	0.09	42	0.06
Calcining	50	44	0.1	32	0.08
Grinding	50	44	1.3	32	0.9

* Gr/dscf was calculated using lb/hr emissions and typical stack gas flow rates.

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4. EMISSION CONTROL TECHNIQUES

The task of minimizing emissions from the complex sequence of operations employed in a typical phosphate rock processing plant usually requires application of several different control systems. At phosphate rock installations, the normal sequence of operations is: mining, beneficiation, conveying of wet rock to and from storage, drying or calcining, conveying and storage of dry rock, grinding, and conveying and storage of ground rock. In general, each operation has a separate control system.

4.1 MINING

Over 98 percent of the phosphate rock produced in the United States is mined from ground where the moisture content is high enough to preclude particulate emissions during extraction of the ore. In the relatively small amount of mining performed in areas where ground moisture content is not sufficient to prevent emissions, such as the hard-rock areas of Utah and Wyoming, some particulate is generated during blasting and handling of the overburden and ore body. These emissions are minimized by wetting the active mining area with water from tank trucks.

4.2 BENEFICIATION

Beneficiation is performed in a water slurry. Since the rock is wet, it does not become airborne and presents no threat to air quality.

4.3 CONVEYING OF WET ROCK

Mined rock is normally moved by conveyor belts. Some are open, others closed for weather-protection. In all except the relatively small plants in the hard rock areas of Utah and Wyoming, the high moisture content of the rock (from 10 to 15 percent by weight)[1] prevents emission of particulate. Weather-protected conveyors also offer some emission control in arid or windy locations.

4.4 PHOSPHATE ROCK DRYING

The air stream from a rock dryer contains particulate and combustion products including moisture. The relatively low temperatures at which the rock is dryed is too low to drive off gaseous fluoride.[2] The effluent is about 160° to 200°F, and the particulate loading is about 3 grains per dry cubic foot.[3] The most common control system is a wet scrubber, although electrostatic precipitators are used by two companies. Examples of the efficiency and emission rate for several collection systems are given in Table 4-1. (Additional details of EPA tests and the results of some sampling conducted by the industry are presented in Appendix C.)

4.4.1 Scrubbers

Scrubbers are the most common control device used by operators of phosphate rock dryers. Probably the most important design parameters for scrubbers are the amount of scrubber water used per unit volume of gas treated (liquid-to-gas ratio) and the intimacy of contact between the liquid and gas phases.[4] The pressure loss across the scrubber is often times used as an indication of the latter. Venturi scrubbers with a relatively low pressure loss (12 inches of water) will have a collection efficiency of 80 to 99 percent for particulates of 1 to 10 microns in diameter and 10 to 80 percent for those less than 1 micron, whereas "high-pressure-drop" scrubbers (30 inches ΔP) may have collection efficiencies of 96 to 99.9 and 80 to 96 percent, respectively, for particles in the same size ranges.[5] As reported in Appendix C, one dryer using a scrubber operated at a pressure drop of 18 inches of water was tested by EPA and found to have emissions of 0.015 gr/dscf. Emissions before the scrubber were about 2 gr/dscf, indicating a control efficiency of greater than 99 percent.

Table 4-1. PARTICULATE EMISSIONS FROM PHOSPHATE ROCK DRYERS

Company	Location	Product Rate Tons/hr	Type of Facility	Control Device[a]	Stack Gas Flow Rate dscfmX10⁻³	gr/dscf	Particulate Emissions lb/hr	Particulate Emissions lb/ton	Remarks
Agrico Chemical	Pierce, Fla.	1,000	NR	IS	800	0.2	138	0.62	Production rate is total for four dryers; lb/ton and gr/scf were calculated using total production, total gas flow and total emissions from all four units.
Beker Industries	Conda, Idaho	63	Fluid Bed	CS	27	0.07	16	0.26	
Borden Chemical	Plant City, Fla.	150	Rotary	C	52	1.2	530	3.5	
Brewster Phosphates	Bradley, Fla.	315	NR	ESP	145	0.15	190	0.60	Production rate is for two dryers. Both are ducted to one ESP.
Conserv, Inc.	Nichols, Fla.	110	NR	IS	27	0.15	35	0.32	
Gardinier, Inc.	Ft. Meade, Fla.	196	NR	ES	77	0.14	92	0.47	
W. R. Grace & Co.	Bartow, Fla.	330 165	Rotary Fluid Bed	IS&ESP IS&ESP	132[b]	0.01	10	0.025[c]	Dryers are ducted to separate scrubbers. The combined scrubber outlet emissions follow one common duct to two parallel ESP's which have separate stacks.
Hooker Chemical	Columbia, Tenn.	21	Rotary	ES	18	0.16	25	1.2	This dryer operates at 400°F (exit gas temperature).
IMC Corporation	Noralyn, Fla.	550	NR NR	CS CS	155[b]	0.07 0.06	47 40	0.16	Production rate is total for two dryers.
IMC Corporation	Kingsford, Fla.	333	Fluid Bed	CS	70	0.04	24	0.08	
Mobil Chemical	Nichols, Fla.	350 350	Rotary Rotary	VS VS	78 78	0.03 0.03	20 20	0.06 0.06	
Occidental Chemical	White Springs, Fla.	242	Fluid Bed	CS	93	0.03	24	0.10	
Rocky Mtn. Phosphates	Garrison, Montana	5	Rotary	VS	NR	NR	NR	NR	This dryer has not been tested. Dryer operates at 250-300°F (exit gas temperature)
J. R. Simplot	Conda, Idaho	150	Rotary	C	22	0.23	42	0.28	This dryer operates at approximately 300°F (exit gas temperature) which is about 100°F hotter than Fla. dryers.
Stauffer Chemical	Leefe, Wyoming	55	Rotary	TS	15	0.10	13	0.24	
Stauffer Chemical	Vernal, Utah	26 26	Rotary Rotary	C C	10 10	1.5 1.1	127 91	4.9 3.5	
Swift Chemical	Bartow, Fla.	178 265	Rotary Fluid Bed	WS CS	56 76	0.40 0.06	191 39	1.07 0.15	
Texasgulf, Inc.	Aurora, N.C.	233	Fluid Bed	C	NR	NR	NR	NR	Emissions from this dryer have never been sampled.
USS Agri-Chem	Ft. Meade, Fla.	187	Rotary	CS	NR	NR	NR	NR	

[a] LEGEND:

C = Cyclone
CS = Cyclonic scrubber
ES - Eductor scrubber
ESP = Electrostatic Precipitator
IS = Impingement scrubber
TS = Spray tower
VS = Venturi Scrubber
WS = Wet Scrubber (generic type not known)
NR = Not reported

[b] Total for two dryers

[c] These dryers averaged 278 and 110 tons per hour production during the tests.

4.4.2 Electrostatic Precipitators

There are currently two operators of phosphate rock dryers which use electrostatic precipitators (ESP's). One uses a conventional dry-type ESP to control emissions from two rotary dryers. The precipitator was designed for 95 percent efficiency, but its operating efficiency is typically about 93 percent.[7] The other operator uses a wet electrostatic precipitator designed and built by MikroPul Division of United States Air Filter Corporation. This unit controls emissions from two dryers, operated in parallel. One is a rotary design and the other is a fluid bed. The control system at this plant is unusual in that emissions from the dryers are first cleaned by two impingement scrubbers (one for each dryer). The streams are then combined and discharge through the ESP. The ESP was designed for an efficiency of 90 percent, but is operating more efficiently because the gas flow rate is approximately half the design value. Simultaneous inlet and outlet tests have not been performed on the dryers, but the operator reports inlet loadings to be 0.6 to 1.0 gr/dscf and EPA tests show outlet emissions to average about 0.01 gr/dscf (98 to 99 percent efficiency). A similar ESP used to collect emissions from an aluminum pot line averaged 98.5 percent efficiency for particulate in the size range 0.2 to 1.0 micron diameter.[8] Ninety-eight percent of the particulate from phosphate rock dryers is larger than 0.4 microns.[9]

Plate (electrode) voltage and the ratio of plate area to the volume of gas treated are the most important variables affecting emissions from electrostatic precipitators. However, the resistivity of the dust in the gas stream being cleaned and the efficiency with which captured material is cleaned from the plates can also affect emissions.

4.4.3 Fabric Filters

Bag filters are not currently used to control emissions from phosphate rock dryers. The industry's apprehension regarding baghouse controls for dryers stems from the high moisture content of the exhaust gases (20 to 30 percent by volume) and the potential "blinding" of bags caused by mixing of moisture and clay material. The industry is concerned the high moisture content would require costly precautionary measures, such as preheating the baghouse before startups and providing auxiliary heat at all times to insure the gas temperature from the dryer does not fall below the dew point in any portion of the baghouse.

In one EPA study[10] to determine the feasibility of more stringent emissions regulations for phosphate rock dryers, it was concluded there are no apparent technical problems which would preclude the use of bag filters for control of dryer emissions. Numerous examples of baghouse installations utilized in similar and more difficult applications are related in this study. The problem of moisture condensation has been resolved in other industries. Typically, condensation is avoided by maintaining a 50°F difference between the wet and dry bulb (W.B. and D.B.) temperature. This can usually be accomplished by insulating all vent lines and the filter. Presently most dryer facilities employ long runs of uninsulated ductwork which is conducive to the formation of condensation. In designing a new plant to use a baghouse, the length of the exhaust gas line from the dryer to the baghouse exit should be minimal and well insulated to minimize heat loss. Control of fuel rate can also help maintain a low relative humidity.

Overheating of the baghouse need not be a problem. For a typical dryer exhaust at 165°F (D.B.) and 30 percent (by volume) water, the temperature of the baghouse should be maintained at about 215°F, well within the acceptable temperature range of most bag fabrics. This temperature could probably be maintained by proper design of the dryer and insulation of the vent lines. However, auxiliary heating may be required for some low temperature dryers. In any case, it would be desirable to provide a temperature control system which would prevent the gas stream from becoming any colder than 50°F above the wet bulb temperature or of exceeding the temperature for which the bag is designed. Other factors such as acidity of the gas stream, and adsorption, adhesion, and electrostatic properties of the particles which could adversely affect the performance of a baghouse can generally be solved by proper selection of the fabric for the bag. Manufacturers of fabric filters consider the gas properties and recommend the proper fabric for a given installation.

Bag filters have become increasingly common as a control device in industries where high collection efficiencies are required. One of the more common applications is on rotary dryers. They are used extensively on dryers at asphalt, cement, and mixed-fertilizer plants; and in the clay industry.[14]

Due to similarities in emissions characteristics (including a composition of mainly clay particles, the experience of the clay industry may be quite applicable to the phosphate rock industry. Nearly all of the kaoline (clay) spray dryers and several of the kaoline rotary kiln dryers in Georgia are equipped with bag filters.[15] The typical particle size from the kaolin dryers is smaller than from a rock dryer -- 80 percent less than two microns as compared to 50 percent less than two microns. The kaolin gas stream typically contains between 20 and 50 percent moisture, a dew-point between 160° and 180°F and a dry bulb temperature between 200° and 250°F.[16]

The Georgia state agency reports that there are no visible emissions for the kaolin rotary kilns or spray dryers when the baghouse is maintained properly.[17] The bag filters used in the kaolin industry are cleaned either by shaking or pulse air. The state agency also reports that operating problems with the filters (such as occasional broken bags) have been minor.[18]

Another application which may be similar to the phosphate rock dryer is the collection of dust from a mixed-fertilizer dryer. Baghouses are used extensively at granular fertilizer manufacturing plants to collect dust from dryers drying various mixtures of triple superphosphate, normal superphosphate, potash, and solid nitrogen compounds.[19] State agency data indicate a dry bulb temperature of 186°F and a wet bulb temperature of 116°F.[20]

Of the two manufacturers contacted, Wheelabrator Frye Corporation and American Air Filter, both indicated that a bag filter could collect the dust from a phosphate rock dryer. They also stated that in their opinion the baghouse has been used successfully on even more difficult applications such as dryers in asphalt plants.[21]

The potential control efficiency of the baghouse on dryer emissions may be estimated by applying fractional efficiency data to the particle size distribution of dryer emissions. Figure 4-1 shows the particle size distribution of particulate matter emitted from three separate dryer facilities. The size distributions are determined with the use of sampling equipment (Brink Cascade Impactor) which separate the stack gas particulate matter into size fractions. The material collected in each size fraction is quantified gravimetrically, and the cutoff particle size for each size fraction (impactor stage) is calculated based on impactor geometry, gas impactor velocity, and particle density. The particle density was assumed to be 2.8 gm/cc, which is consistent with the density of the known major components in the emissions stream (apatite and clays) and the value commonly used by the industry in developing design specifications for emission collection equipment.[25,39] The size of particles in the dryer emissions shown in Figure 4-1 are relatively fine due to the composition of the phosphate ore (Florida pebble rock) processed. The pebble rock contains relatively soft clays which disaggregate readily, resulting in the generation of fine particles. Emissions from pebble rock dryers are of major concern, since the substantial portion of phosphate rock production occurs in Florida.

Figure 4-2 shows the effect of particle size on collection efficiency of the bag filter. The efficiency plot was developed from test data for a baghouse performing under control conditions similar to those produced by phosphate rock dryers. The performance of fabric filter collectors is relatively unaffected by the size distribution of particulates. By contrast, particle size exerts a substantial impact on the performance of scrubbers, as seen in Figure 4-2 (estimated by utilizing an analytic scrubber model developed by EPA[40]). Based on the two particle size

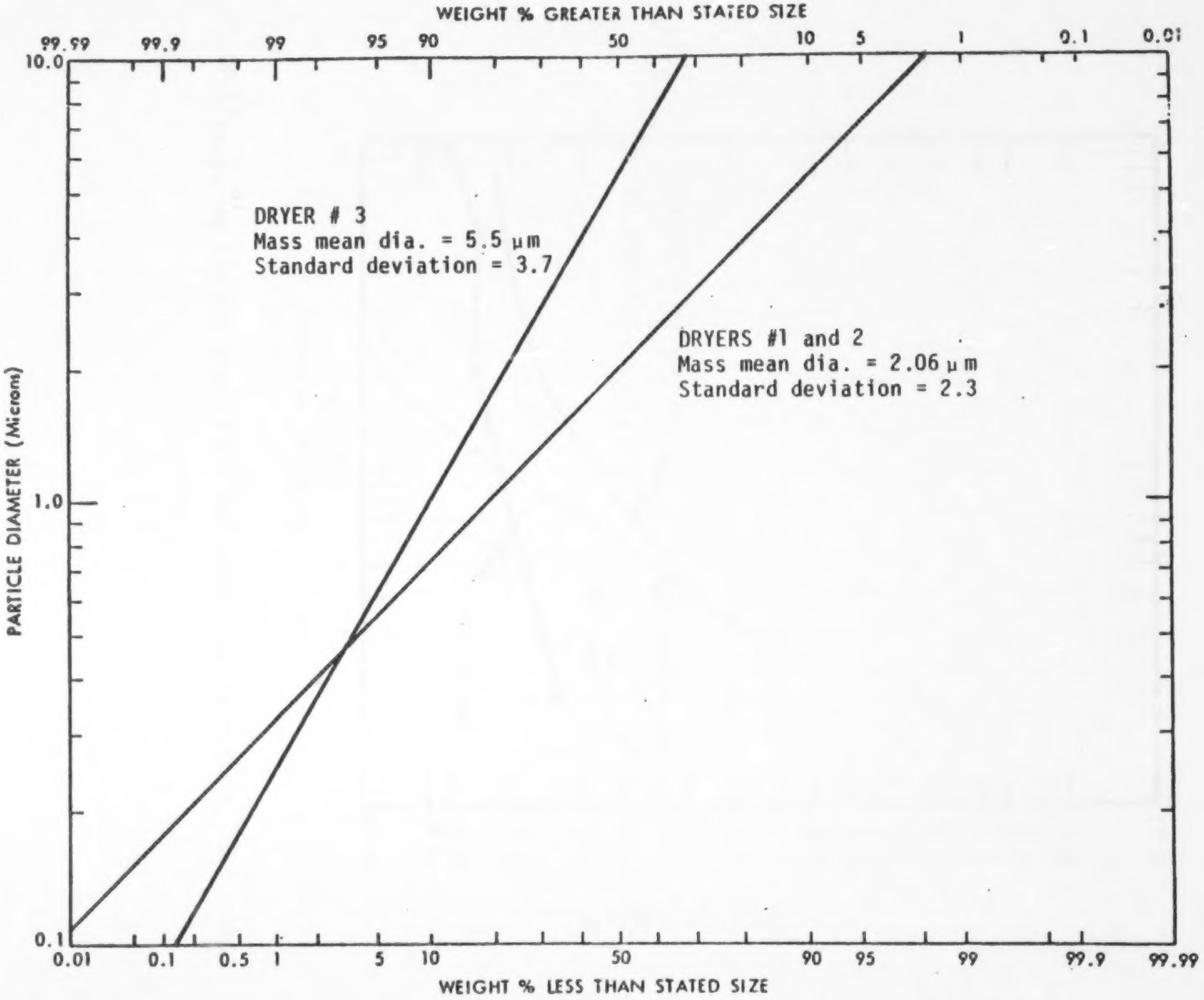

Figure 4-1. Particle size distribution for phosphate rock dryer emissions[11,41].

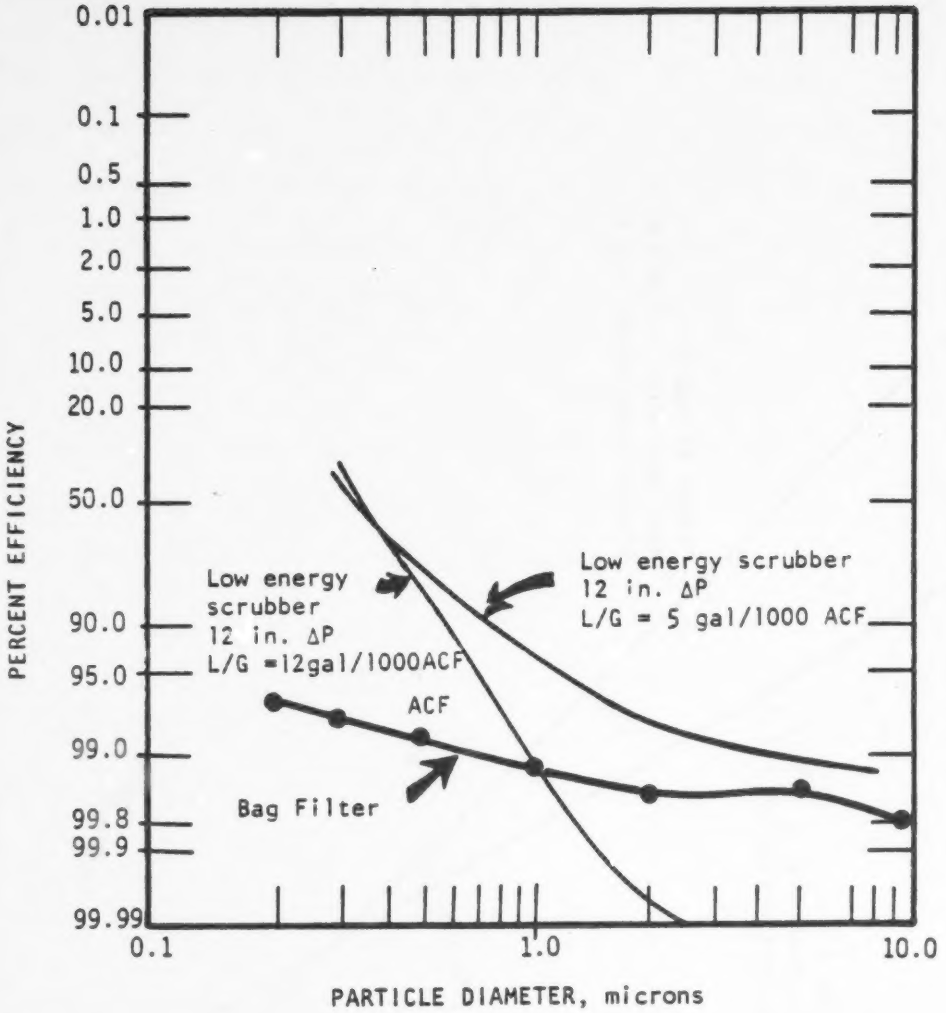

Figure 4-2. Fractional efficiency for bag filters and wet scrubbers.[12,40]

distributions shown in Figure 4-1, and the performance curve of Figure 4-2, the overall efficiency of a baghouse treating dryer emissions would be 99.0 to 99.4 percent (estimated by summing the partial efficiencies for selected particle size increments). By contrast, the low energy scrubber (12 inches of water pressure drop), which is typically used throughout the industry, attains an estimated overall efficiency of 93.6 to 96.5 percent, depending on the liquid to gas ratio employed. However, the scrubber can achieve collection efficiencies equivalent to the baghouse when designed suitably (i.e., for high energy and liquid to gas flow rates).

4.5 PHOSPHATE ROCK CALCINERS

As discussed in Chapter 3, calciners and dryers process the same feed material, phosphate rock. The major differences between the two processes are the final temperature to which the rock is heated (200°F for dryers and up to 1600°F for calciners) and the exhaust gas temperatures (about 165°F for dryers and 200°F to 700°F for calciners). The particulate concentration from the processes are about the same (0.5 to 5 gr/dscf) and, as shown in Table 4-2, the size distribution of the particulates in the exhaust gases is similar.

Table 4-2. PARTICLE SIZE DISTRIBUTION OF EMISSIONS FROM PHOSPHATE ROCK DRYERS AND CALCINERS

	Percent Less Than Stated Size	
Diameter, Microns	Dryers[a]	Calciners[25]
10	82	96
5	60	81
2	27	52
1	11	26
0.75	7	10
0.5	3	5

[a] Compiled as the mid point of the range of size distributions observed at different phosphate rock dryers[5,41]

Because of the similar characteristics of the particulate matter in the exhaust gases from dryers and calciners, it is expected that the "controllability" of emissions from the two processes is similar, and that control technology for dryers can be applied to emissions from calciners. Emissions from the control devices of the two processes, including the opacity of the emissions, should be the same when controlled to the same degree.

The gas stream leaving the calciner is usually passed through a cyclone to a particulate control device. One company is using an electrostatic precipitator, but the most common control device is a wet scrubber.

4.5.1 Scrubbers

Scrubbers are popular for controlling emissions from phosphate rock calciners because they are reportedly "less sensitive to damage caused by the high temperature of the calciner exhaust."

4.5.2 Electrostatic Precipitators

Only one calciner now uses an ESP to control emissions. The ESP is two-stage and operates with an inlet particulate loading of about 5 gr/dscf and an outlet loading of about 0.05 gr/dscf, about 99.0 percent efficient.[26] Factors affecting the performance of an ESP were discussed in Section 4.4.2.

4.5.3 Fabric Filters

Bag filters are not currently used to control emissions from phosphate rock calciners. As in the case of rock dryers, the industry is apprehensive of overheating of the bags due to high exhaust temperatures, and potential blinding of the bags due to mixing of moisture and clay material.

In one EPA study[10] concerning the control of emissions from phosphate rock dryers, it was concluded there were no apparent technical problems which would preclude the use of bag filters for control of dryer emissions. Because the controllability of dryer and calciner emissions is similar, it is expected that bag filters would also be applicable for control of calciner emissions. Baghouse installations are currently used in numerous applications similar to the service which would be required for phosphate rock calciners. The high exhaust gas temperatures are controlled by a variety of approaches in other industries, such as radiation type coolers (used in metallurgical industries[27]), water spray, or dilution with ambient air. The problem of moisture condensation is typically resolved by maintaining approximately a 50°F temperature difference between the wet and dry bulb temperature. For emergency protection of the baghouse filters, a relief system is used to vent high temperature exhaust gases if the temperature control system fails. Such emergency equipment is reliable and relatively inexpensive compared to the costs of replacing damaged filters. In addition to temperature protection afforded by gas conditioning, special nylon or fiberglass textile filter fabrics capable of service at 450°F may also be used as a protective measure against transient temperature peaks. The control system manufacturer considers the economic tradeoffs associated with the alternative baghouse designs and recommends a suitable fabric and gas conditioning system.

The potential control efficiency of a baghouse for calciner emissions may be estimated by applying fractional efficiency data to the particle size distribution of calciner emissions. Since the particle size distribution and composition of calciner and dryer emissions is similar, the collection efficiency of the baghouse for the dryer and calciner applications is similar. Based on the size distribution of calciner exhaust particles given in Table 4-2, and the bag filter performance curve of Figure 4-2, and the bag filter performance curve of Figure 4-2, the overall efficiency of a baghouse treating calciner emissions would be 99.0 percent. The efficiency of low energy scrubbers normally used to control calciner emissions in the industry is somewhat lower (about 94 to 97 percent).

4.6 GRINDING

Dried and calcined rock is ground prior to being used for the manufacture of fertilizers, as described in Chapter 3. The grinding or milling circuit operates under slightly negative pressure to prevent the escape of air containing ground rock. Because the system is not airtight, some air is drawn into the system and must be vented. This vent stream is usually discharged through a fabric filter (baghouse), although a wet scrubber is also sometimes employed. The temperature of the air is typically about 125°F and contains particulate matter.

The grinding operation is purely mechanical and there is no threat of fluoride evolution other than as a part of the particulate.

4.6.1 Scrubbers

Scrubbers are sometimes used to control emissions from grinders. They are usually low-energy (8 to 10 inches pressure drop) Venturi or impingement scrubbers. Emissions from these devices are typically about

Table 4-3. PARTICULATE EMISSIONS FROM PHOSPHATE ROCK CALCINERS[29]

Company	Location	Production Rate Tons/Hr	Type of Calciner	Control Device	Stack Gas Flow Rate scfm x 10^{-3}	Particulate Emission Rate Gr/dscf	lb/hr	lb/ton
Beker Industries	Conda, Idaho	70	Fluid Bed	VS	34	0.03	8.8	0.13
		70	Fluid Bed	VS	40	0.10	34	0.49
Mobil Chemical	Nichols, Florida	50	Rotary	IS	55	0.05	25	0.5
J. R. Simplot	Pocatello, Idaho	35	Fluid Bed	IS	25	0.3	64	1.8
		41	Fluid Bed	CS	28	0.1	24	0.58
		55	Fluid Bed	ESP	58	0.06	30	0.54
Stauffer Chemical	Leefe, Wyoming	20	Fluid Bed	C	17	1.54	225	11.25
		20	Fluid Bed	C	17	1.20	175	8.75
		30	Fluid Bed	C	29	0.63	158	5.26
Texasgulf, Inc.	Aurora, N.C.	60	Fluid Bed	VS	53	0.04	16.4	0.27
		60	Fluid Bed	VS	53	0.04	16.4	0.27
		60	Fluid Bed	VS	53	0.04	16.4	0.27
		60	Fluid Bed	VS	53	0.04	16.4	0.27

[a]LEGEND:

C = Cyclone
CS = Cyclonic Scrubber
ESP = Electrostatic Precipitator
IS = Impingement Scrubber
VS = Venturi Scrubber

10 times greater than for fabric filters. Scrubbers also add to the volume of effluent water which must be treated before discharge.

4.6.2 Electrostatic Precipitators

Electrostatic precipitators have not been used to control emissions from phosphate rock grinders.

4.6.3 Fabric Filters

Fabric filters are the most common device used to control emissions from grinders. This is probably because the particulate collected by the baghouse can be added directly to the product, thereby increasing yields. Also, the low moisture content and only slightly elevated temperature (125° to 150°F), eliminates the reasons industry claims for avoiding the use of baghouses on dryers and calciners. Table 4-4 presents typical emission rates for grinders. Details of EPA tests and results of some industry tests are presented in Appendix C. The operators report no variation in emissions as a result of such factors as fineness of grinding, type of rock, ambient conditions, or any other equipment or process variable which can be controlled.[30]

Variations in emissions from one unit to another at a given location appear a function only of the total volume of exhaust air (Table 4-4). For a given fabric filter, evidence suggests that the discharge loading is fairly constant over a range of air flows. If true, the mass emission rate is proportional to the total gas volume. The largest source of variation in emissions is, of course, the differences in design parameters and maintenance of the particular devices cited. The reader is referred to Control Techniques for Particulate Air Pollutants[23] for additional detail about the design and operation of control devices.

Table 4-4. PARTICULATE EMISSIONS FROM PHOSPHATE ROCK GRINDERS[31]

Company	Location	Production Rate Tons/Hr	Number of Mills	Type of Mill	Control Number	Device Type	Stack Gas Flow Rate scfm X 10-3[b]	Particulate Emissions gr/scf[c]	Particulate Emissions lb/hr[b]	Particulate Emissions lb/ton	Remarks
Agrico Chemical	Pierce, Florida	173	6	Roller	6	BH	20.4	0.05-0.2	15	0.09	
Beker Industries	Conda, Idaho	60 75	1 2	Ball Ball	1 2	BH BH	3.8	0.003 NR	0.11 NR	0.002 NR	Emissions from two of the three ball mills have never been sampled. The plant used EPA Method 5 to sample the third mill.
Brewster Phosphates	Bradley, Florida	NR	2	Roller	1	BH	7.1	0.0036	0.22	NR	
Farmland Industries	Bartow, Florida	110	1	Ball	1	BH	14.4	0.008	1.0	0.009	
Gardinier, Inc.	Tampa, Florida	235	1 5	Roller Roller & Ball	1 5	IS BH	9.6 32.3	0.11 0.016-0.070	9.4 11.0	0.08	Production rate and lb/ton emissions are for all six mills.
W. R. Grace and Co.	Bartow, Florida	45 155	3 2	Roller Ball	1 1	WS	16.3 12.2	0.06 0.08	7.0 8.0	0.15 0.05	
IMC Corporation	Noralyn, Florida	240	7	Roller & Ball	5	BH	40.0	0.08	27.0	0.11	
IMC Corporation	Kingsford, Florida	110	3	Roller	2	VS	21.0	0.17	32	0.29	
Mobil Chemical	Nichols, Florida	209	4	Roller	2	WS	8.0	0.2	11	0.044	
Occidental Chemical	White Springs, Fla.	124	1	Ball	1	BH	13.6	0.010	1.10	0.009	
Royster Company	Mulberry, Florida	65	2	Roller & Bowl	1	BH	6.3	0.003	0.2	0.003	One baghouse cleans emissions from both mills. Emission tests performed using WP-50 method with slight variations
J. R. Simplot	Pocatello, Idaho	100	6	Roller	3	BH	34.0	0.003-0.007	1.33	0.013	
Stauffer Chemical	Leefe, Wyoming	40	3	Roller	3	BH	NR	NR	NR	NR	Emissions from the mills have never been sampled.
Swift Chemical	Bartow, Florida	45	3	Roller	3	WS	6.0	0.06-0.15	6.4	0.13	
Texasgulf, Inc.	Aurora, N.C.	150	2	Ball	2	BH	24.0	0.15	30.9	0.21	Mill's have never been sampled for emission.
USS Agri-Chem	Bartow, Florida	45	3	Roller	5	BH	9.1	0.086	6.6	0.147	
USS Agri-Chem	Ft. Meade, Florida	75	4	Roller	5	BH	9.8	0.002	0.13	0.002	

[a] LEGEND:
BH = Baghouse
IS = Impingement Scrubber
VS = Venturi Scrubber
WS = Wet Scrubber (Generic Type Not Known)
NR = Not Reported

[b] Total from all mills.
[c] Range for all mills.

4.7 MATERIALS HANDLING AND STORAGE

Emissions from materials handling systems are difficult to quantify, partially because of the great number of different systems employed to convey rock, and partially because a large part of the emission potential for these operations is fugitive emissions. Materials handling systems range from "front-end loaders" and other manual conveyances to automated pneumatic systems. The basic differences between the systems from an emissions standpoint are the precautions taken to prevent the dust from becoming airborne and the ease with which it can be captured if it does.

The most common type of transfer system for unground rock consists of conveyor belts and bucket elevators. In order to minimize fugitive emissions caused by ambient air currents, conveyor belts moving dried rock are usually covered and sometimes enclosed. The major source of emissions from this type of system is the "transfer point" where the material falls by gravity from the conveyor belt. Small amounts of fugitive dust can also be present at points along the housed enclosure because of the movement of the belt over the rollers, thermal air currents created by the hot rock, or ambient winds. Transfer points are sometimes hooded and evacuated to minimize fugitive emissions, but none in the phosphate rock industry have been seen which are 100 percent efficient. Some conveyors used for similar applications in the crushed-stone industry, however, do control transfer points to the point of no visible emissions.[32]

Bucket elevators are usually enclosed and evacuated to a control device since otherwise they would generate substantial amounts of dust.

Rock which has been ground is usually conveyed in totally enclosed systems, such as described in Chapter 3. These systems are very effective at limiting fugitive emissions since discharge points of material and of particulate-laden air are well defined and easily controlled. In essentially all cases, particulate emissions can be effectively controlled by proper maintenance of the transfer system and its control device. Since the pneumatic systems operate under positive pressure, monitoring of emissions from the control device is the only necessary means for enforcement of a visible emission standard. A leak in the transfer system itself will require immediate attention of plant personnel to minimize product loss.

Dry rock, both ground and unground, is normally stored in enclosed bins or silos which are vented to the atmosphere. Emissions from the vents are frequently controlled by fabric filters. For pneumatic ground rock handling systems, this is the same fabric filter which controls emissions from the transfer system. The dust they collect is returned to the silo.

The emissions potential for a typical materials handling and storage system is estimated as 2 pounds per ton of rock handled.[33] The control of air pollution must be a priority item in the design of new materials handling systems since retrofitting is often costly and difficult because of space limitations and often results in a less efficient system.

4.8 WET GRINDING

The most promising "air pollution control technique" for dryers and calciners is the recent move toward wet grinding of rock for the manufacture of wet-process phosphoric acid (WPPA). The rock is ground in a water slurry and then added to the WPPA reaction tanks without drying. This has not been done previously because the water entrained with the ground rock would require a stronger acid in the WPPA reaction (or be removed by evaporation) to maintain the 54-percent P_2O_5 strength needed for production of fertilizer. Historically, 93-percent sulfuric acid has been diluted to 58-percent for the WPPA reaction prior to addition to the reactor to permit removal of the heat of dilution. If added to the reactor at 93 percent strength, the heat of dilution coupled with the heat of reaction would exceed the capacity of the vacuum flash cooler used for temperature control. Also, it was widely accepted that the higher temperatures would result in formation of smaller crystals of waste gypsum which would complicate the separation of product acid from waste gypsum.

Two companies have now overcome their reservations about the wet grinding process. They have designed larger flash coolers on the reactors to remove the heat of dilution, and have found no significant difference in the crystal size of the gypsum.[34] The products from the reactor are fed to the evaporators at 28 to 32-percent P_2O_5 acid, the same as the conventional WPPA process.

The only significant problem created by wet grinding is the water balance around the plant. EPA's effluent water regulations require zero discharge by 1980. Wet grinding adds about 300 gallons per minute to an effluent discharge volume which operators of WPPA plants are already finding difficult to control. However, the potential savings (elimination of the energy intensive phosphate rock dryer and its air pollution control system and air pollution controls for the grinder) is a strong incentive to the operator.

Plant management contends that the major driving force for the process is not improvements in technology, but increasingly expensive fuel costs and stringent air emission regulations.[35] It is now less expensive to treat the wet rock than to contend with high energy costs and increasingly stringent air regulations.

The impact of the wet grinding process could be far-reaching since about 70 percent of all phosphate rock is ultimately used to produce fertilizer,[36] and 85 percent of the rock used for fertilizer must first be converted to phosphoric acid.[37] If wet grinding proves to be a trend in the industry (and present indications are that it will),[38] the growth rate for phosphate rock dryers will become negligible. Of course, there will continue to be a requirement for dry rock unless ways are found to introduce wet ground rock into the processes other than WPPA. Much of this need may be filled by the capacity of existing dryers rather than construction of new ones. The need for emission controls on phosphate rock grinders, though diminished, will continue since the calcination process will probably continue at its current rate of growth and calcined rock must be ground.

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5. MODIFICATION AND RECONSTRUCTION

In accordance with Section 111 of the Clean Air Act, standards of performance shall be established for new sources within a stationary source category which "...may contribute significantly to air pollution ..." Standards apply to operations or apparatus (facilities) within a stationary source, selected as "affected facilities," that is, facilities for which applicable standards of performance have been promulgated and the construction or modification of which commenced after the proposal of said standards.

On December 16, 1975, the Agency promulgated amendments to the general provisions of 40 CFR Part 60, including additions and revisions to clarify modification and the addition of a reconstruction provision. Under the provisions of 40 CFR 60.14 and 60.15, an "existing facility" may become subject to standards of performance if deemed modified or reconstructed. An "existing facility" defined in 40 CFR 60.2(aa) is an apparatus of the type for which a standard of performance is promulgated and the construction or modification of which was commenced before the date of proposal of that standard. The following discussion examines the applicability of these provisions to phosphate rock processing facilities and details conditions under which existing facilities could become subject to standards of performance. It is important to stress that since standards of performance apply to affected facilities which, combined with existing and other facilities comprise a stationary source, the addition of an affected facility to a stationary source through any mechanism, new construction, modification or reconstruction, does not make the entire stationary source subject to standards of performance, only the added affected facility.

5.1. 40 CFR PART 60 PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1. Modification

It is important that these provisions be fully understood prior to investigating their applicability.

Section 60.14 defines modification as follows:

> "Except as provided under paragraphs (e), and (f) of this section, any physical or operational changes to an existing facility which result in an increase in emission rate to the atmosphere of any pollutant to which a standard applies shall be a modification. Upon modification, an existing facility shall become an affected facility for each pollutant to which a standard applies and for which there is an increase in the emission rate".

Physical changes in equipment design such as a modification of the dryer flights to increase gas-to-solids contact or the replacement of a totally enclosed ground rock transfer system with an open system would probably subject the operator to the provisions of Section 60.14 since emissions from the equipment would increase.

Paragraph (e) lists certain physical or operational changes which will not be considered as modifications, irrespective of any change in the emission rate. These changes include:

1 - Routine maintenance, repair and replacement.

2 - An increase in the production rate not requiring a capital expenditure as defined in Section 60.2(bb).

3 - An increase in the hours of operation.

4 - Use of an alternative fuel or raw material if prior to the standard, the existing facility was designed to accommodate that alternate fuel or raw material.

5 - The addition or use of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or replaced by a system considered to be less efficient.

Paragraph (b) clarifies what constitutes an increase in emissions in kilograms per hour and the methods for determining the increase, including the use of emission factors, material balances, continuous monitoring systems, and manual emission tests. Paragraph (c) affirms that the addition of an affected facility to a stationary source does not make any other facility within that source subject to standards of performance. Paragraph (f) simply provides for superceding any conflicting provisions.

5.1.2 Reconstruction

Section 60.15 regarding reconstruction states:

> "If an owner or operator of an existing facility proposes to replace components, and the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, he shall notify the Administrator of the proposed replacements. The notice must be postmarked 60 days (or as soon as practicable) before construction of the replacements is commenced. . . ."

The purpose of this provision is to ensure that an owner or operator does not perpetuate an existing facility by replacing all but vestigial components, support structures, frames, housings, *etc.*, rather than totally replacing it in order to avoid subjugation to applicable standards of performance. As noted, upon request, EPA will determine if the proposed replacement of an existing facility's components constitutes reconstruction.

5.2 Applicability to Phosphate Rock Processing Operations

5.2.1 Modification

The following physical or operational changes will not be considered as modifications to existing phosphate rock plants, irrespective of any change in the emission rate:

1. Changes determined to be routine maintenance, repair, or replacement. For phosphate rock processing plants, this will include the replacement or refurbishing of equipment elements subject to high heat or abrasion and impact such as refractory linings, crushing surfaces, screening surfaces, and conveyor belts.
2. An increase in the production rate if that increase can be accomplished without a capital expenditure exceeding the existing facility's IRS annual asset guideline repair allowance of 6.5 percent per year.
3. An increase in the hours of operation.
4. Use of an alternative raw material, such as Florida land pebble, if the existing facility was designed to accommodate such material.
5. Use of an alternative fuel, such as switching from natural gas to fuel oil, if the existing facility was designed to accommodate the alternate fuel. If the facility was not so designed, the switch would be considered a modification unless it could be demonstrated

that the new fuel did not result in an increase in emissions. However, conversion to coal required for energy considerations, pursuant to Section 113(d) (5) or Section 119 (as in effect before the date of enactment of the Clean Air Act Amendments of 1977) of the Act, shall not be considered a modification.

6. The addition or use of any air pollution control system except when a system is removed or replaced with a system considered to be significantly less effective.

The impact of the modification provision on existing phosphate rock facilities should be very slight. Except as noted above, no condition is foreseen which would deem an existing phosphate rock processing facility modified.

5.2.2 Reconstruction

The replacement of facility components could be considered reconstruction if the fixed capital cost of replacement exceeds 50 percent of the cost to construct an entirely new facility.

One action which could be considered reconstruction for a dryer, calciner, grinder or ground rock transfer system would be the replacement and extensive refurbishing of power plant and drive mechanism, including motor, chains, belts, gears, couplings, reducers, clutches, bearings, etc. In such case, the test involving the relationship between the fixed capital cost of the replacement versus the corresponding costs for complete reconstruction of the facility should be used to determine applicability of the reconstruction provision. The final determination will be made by the EPA Administrator based on information provided by the owner.

Replacement of facility components which are subjected to extreme heat (e.g., refractory linings) or attrition due to abrasion or impact (e.g., crushing surfaces, screening surfaces and conveyor belts) could be considered routine maintenance and may therefore be exempted by the reconstruction and modification provisions.

CHAPTER 6. ENVIRONMENTAL IMPACT

6.1 INTRODUCTION

This chapter identifies and analyzes the environmental impacts of alternative emission control systems as applied to the phosphate rock processing industry. Incremental impacts on air, water, solid waste, and energy resulting from the use of alternative control systems are assessed. The short-term versus long-term trade offs, including resources commitments, of the alternative control systems are described and compared for each impact analysis. Impacts of establishing emission standards (based upon application of the different control systems) are compared with the impacts of not proposing or promulgating standards of performance for new sources.

Those processes within the phosphate rock processing industry that are included in the impact analysis are drying, calcining, grinding and ground product materials handling. Processes not considered, and hence, not included in the impact statement, are mining and beneficiation. Descriptions of these processes are in Chapter 3.

The alternative control systems under consideration as the best demonstrated controls for the phosphate rock processing industry are the high efficiency electrostatic precipitator (ESP), fabric filters (baghouses) and high energy scrubbers. Each of these devices is currently used by the industry to control emissions; however, their application is usually process specific. Scrubbers, for example, are the most common control device for emissions from dryers and calciners, although most are low energy devices (8 to 10 inches of water), whereas baghouses are commonly used to control emissions from grinding and materials handling. Baghouses are not currently being used to control emissions from dryers and calciners. From the similarity between the emission characteristics from phosphate rock dryers and calciners and similar operations in other industries, such as clay and kaolin dryers, it is believed that fabric filter application on phosphate rock dryers and calciners is feasible an and could achieve high particulate control efficiencies. Additional discussion on the alternative control system is presented in Chapter 4.

6.2 ENVIRONMENTAL IMPACT OF STANDARDS OF PERFORMANCE

6.2.1 Air Impact

The air impact resulting from the application of the alternative control systems is evaluated by considering the incremental reduction in particulate emissions beyond that achieved to meet state implementation regulations.

6.2.1.1 Emissions Limited by State Implementation Regulations

State Implementation regulations that are of concern for this industry are limited to eight states: Florida, Tennessee, Idaho, Montana, Utah, Wyoming, California, and North Carolina. Mass emissions of particulates from rock processing plants in six of these states are limited to a general process weight rate regulation. These regulations are illustrated in Figure 6-1. Another state uses the criteria of best available equipment that is reasonable and practical; in the eighth state (California), each county sets its own regulations. In all cases where process weight rate is used, the regulations become more stringent as the process weight rate increases. Six

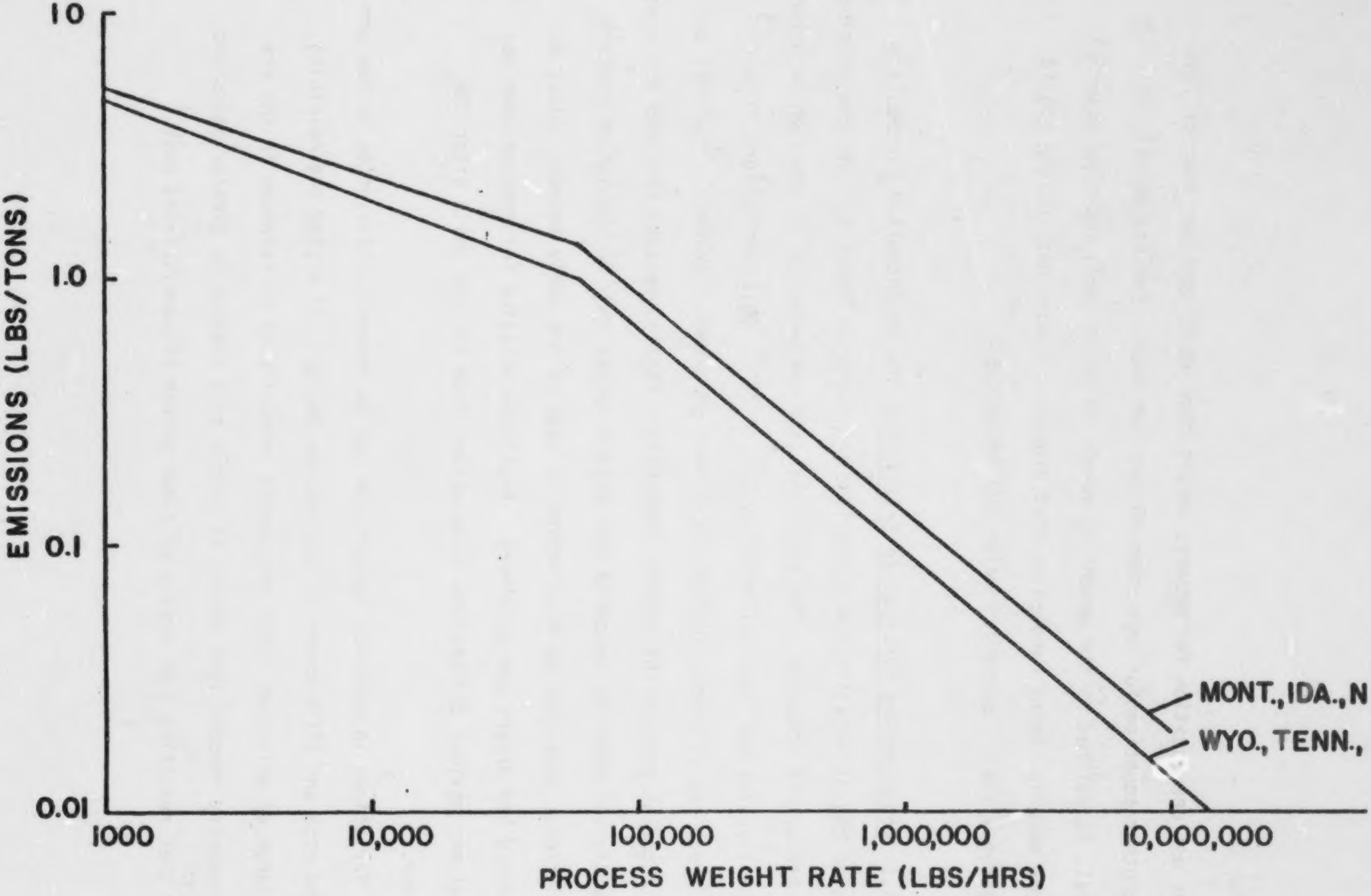

Figure 6-1. Particulate emissions as restricted by State Implementation Plans.

states use one equation for process weight rate of 30 tons per hour or less and another equation for more than 30 tons per hour. Process weight, in general, is defined as the amount by weight of solid fuel, recycled material and raw material being handled in that process; it does not include liquid and gaseous fuels, uncombined water and process air.

6.2.1.2 Uncontrolled Particulate Emissions - The uncontrolled particulate emission characteristics are summarized by source in Table 6-1 for the phosphate rock processing industry. The emissions data are based on information reported by the industry and data collected by EPA.[1,2,3,4] Emission factors listed for dryers and calciners include the effect of primary cyclones. Cyclones are considered as part of the process equipment. This is because cyclones are used primarily for material recovery and recycle rather than for pollution control. Furthermore, note that no distinction is made in the table between rotary and fluidized bed dryers and calciners. Available emission information does not reveal any obvious differences in emissions from the two units after the cyclone.

Variations in emission factors are due to inherent differences in the processed rock and differences in the process design. In drying and calcining, the range of emissions rates are caused primarily by differences in the ore. The industry reports that drying of pebble rock results in greater emissions than that resulting from drying of other grades of beneficiated rock.[1]

Table 6-1. TYPICAL CHARACTERISTICS OF EMISSIONS FROM UNCONTROLLED PHOSPHATE ROCK PLANT SOURCES

	Particulate Emissions			Typical Stack Gas Characteristics			Particle Size	
	Range	Typical Emissions						
Source	gr/scf	gr/scf	lb/ton	Temp. (°F)	Percent Water	DSCF/ ton	MMD	S_g
Drying	0.5-5.0	2.0	5.7	165	10-30	20,000	3.8µm	3.0
Calcining	0.5-5.0	2.0	15.4	250	10-30	54,000	1.9µm	2.5
Grinding	0.5-5.0	2.0	1.5	125	1-10	5,400	12 µm	4.0
Ground Rock Handling	0.5-10.0	2.0	1.4	120	1-10	5,000	12 µm	4.0

Compared to other ores, pebble rock is softer and more easily disintegrated by attrition, and contains more submicron clay particles which are easily suspended. During the process of calcining, the greater emission loadings are experienced during processing of unbeneficiated rock.

The emission information for dryers and calciners presented in Table 6-1 represents emission characteristics for units that are direct-fired with fuel oil or natural gas. The emission rates, gas flow rates, and temperatures presented are the median of the ranges observed in the industry, and are assumed to be typical values. The variations in exhaust gas volumes for dryers and calciners are relatively small (± 20 percent) whereas variations in the the values for grinders and ground rock handling are larger. Energy considerations are believed to be responsible for the smaller variation in values for dryers and calciners; large variations in values for grinding and ground rock handling are probably due to variations in process design.

The particle size information in Table 6-1 (i.e., mass median diameters, MMD, and standard geometric deviations, S_g, for log-normal distributions) are based on particle sizing tests of emissions from dryers, calciners and grinders.[1,5,6,7] The values presented are the midpoint of the ranges observed for particulate emissions from phosphate rock plants and are assumed to be representative of "typical" phosphate rock facilities. For those sources where only a single particle sizing test was conducted the distribution provided by that test was assumed representative. The particle size distributions for emissions from material handling were assumed equivalent to those for grinders.

6.2.1.3 Particulate Emissions Levels Achievable Using Alternative Control Systems - The emissions levels which are achieved when the alternative control systems are applied to typical uncontrolled emission sources are shown in Table 6-2. The overall collection efficiencies of the baghouse and ESP alternatives are estimated by applying fractional efficiency data available in the literature[1] to the typical particle size distribution given in Table 6-1. The collection efficiency of the scrubber alternatives is estimated by applying an EPA venturi scrubber model which utilizes as inputs the assumed scrubber operating condition and typical emissions characteristics.[8] The predicted emission levels associated with each control alternative are consistent with emissions levels observed at phosphate rock facilities presently employing the candidate control systems (see Appendix C).

It should be noted that both the ESP and scrubber are capable of achieving control efficiencies equivalent to that attained by the fabric filter. This is accomplished by designing the control system for the expected emissions characteristics. Alternative designs will result in different collection efficiencies, different capital and operating costs, and possibly different environmental impacts. Because the analyses of control alternatives is concerned with selection of the best system of emissions reduction considering cost and nonair environmental impacts, the less efficient versions of the scrubber and ESP are also considered in the analysis as candidate control systems.

6.2.1.4 Particulate Emission Reductions Resulting from Alternative Control Systems - To estimate the impact of the alternative control systems on emissions levels, it is necessary to determine the total amount of industrial production

Table 6-2. PARTICULATE REMOVAL EFFICIENCIES AND EMISSIONS LEVELS ACHIEVABLE FOR ALTERNATIVE CONTROL SYSTEMS

Source	Alternative Control System		Overall Collection Efficiency (percent)	Controlled Emissions Levels	
				lb/ton	gr/scf
Dryer	Fabric Filter		99.3	0.04	.014
	High Energy Scrubber[a]	(ΔP=25")	99.3	0.04	.014
	Medium Energy Scrubber[a]	(ΔP=12")	98.3	0.10	.034
	High Efficiency ESP		99.3	0.04	.014
	ESP		98.3	0.10	.034
Calciner	Fabric Filter		99.0	0.15	0.02
	High Energy Scrubber[a]	(ΔP=27")	99.0	0.15	0.02
	Medium Energy Scrubber[a]	(ΔP=12")	96.5	0.54	0.07
	High Efficiency ESP		99.0	0.15	0.02
	ESP		96.5	0.54	0.07
Grinder	Fabric Filter		99.6	0.006	0.008
	High Energy Scrubber[a]	(ΔP=16")	99.6	0.006	0.008
	Medium Energy Scrubber[a]	(ΔP=12")	99.4	0.009	0.012
	High Efficiency ESP		99.6	0.006	0.008
	ESP		99.4	0.009	0.012
Ground Rock Handling	Fabric Filter		99.6	0.006	0.008
	High Energy Scrubber[a]	(ΔP=16")	99.6	0.006	0.008
	Medium Energy Scrubber[a]	(ΔP=12")	99.4	0.008	0.012
	High Efficiency ESP		99.6	0.006	0.008
	ESP		99.4	0.008	0.012

[a] Assumed to be a venturi scrubber operating at a liquid to gas ratio of 12 gal/1000 ACF and a pressure drop as indicated. Characteristics of the emissions stream are assumed equivalent to "typical" levels presented in Table 6-1.

Note: The emissions levels permitted by typical state implementation regulations are: 0.26 lb/ton for dryers, 0.88 lb/ton for calciners and grinders, and 0.20 lb/ton for ground rock handling systems. Based on typical gas flow rates, these levels correspond to concentrations of 0.09 gr/scf for dryers, 0.11 gr/scf for calciners, 1.14 gr/scf for grinders, and 0.29 for handling systems.

which will be affected by the New Source Performance Standard. The standard will apply to: 1) new plants, 2) processes with existing plants that undergo major modifications, and 3) new processes within a plant that are a result of expansion.

New sources resulting from plant expansion and from new plants (Items 1 and 3 above) are expected to total about 5 percent per year based upon production figures from 1950 compared to those projected for 1980.[9,10] Hence, if TPW_n is the total (industry) process weight of phosphate rock for the nth year following promulgation of standards, this growth of new sources can be expressed as TPW_o $(1.05^n - 1)$, where TPW_o represents production for the base year corresponding to $n=0$. Based upon a 20-year life expectancy of existing process equipment, new sources due to major in-plant modifications would be 5 percent per year of the base year production (TPW_o). Hence, new sources resulting from major in-plant modifications can be expressed as $n(0.05\ TPW_o)$. Therefore, the total of new source process weight for the nth year (NS_n) after promulgation of new source standards can be expressed as follows:

$$(NS_n) = \{[(1.05)^n - 1] + n\ (0.05)\}\ (TPW_o)$$

The new source yearly process weight predicted by this equation, using the base year of 1975, where (TPW_o) = 56,700,000 short tons,[9] are in thousands of short tons:

n	1	5	10	20
NS_n	5,700	29,800	64,000	122,100
TPW_n	59,500	72,400	92,400	150,400

The predicted total process weight (TPW_n) for the industry is also included for comparison purposes.

Processing of production from new sources will be by various schemes (e.g., drying, calcining, etc.). Hence, in assessing the impact, it is necessary to anticipate the percent of new source production by the various processes. Based on available data for current production by various processes, 90 percent of process weight from new sources will be processed through dryers and 10 percent in calciners. Furthermore, 90 percent of the process weight from new sources is assumed to be ground and is throughput for ground rock handling. Based on application of the various candidate emission control systems, and the typical gas characteristics of emissions presented earlier (Table 6-1), the total emissions from new sources are projected for 1, 5, 10, and 20 years into the future. These results are presented in Table 6-3 in tons/year.

The impacts of the various control alternatives on source emissions levels are given in Table 6-4 in terms of the difference between the emissions allowed by typical state implementation regulations and the typical source emissions levels resulting from the various control alternatives. Using the results presented in this table, the new source production rates given earlier and throughputs of 90, 10, 90, and 90 percent for drying, calcining, grinding and ground rock handling, respectively, the reduction in totals emissions can be estimated. These total reductions in emissions are presented in Table 6-5. The results of Tables 6-3 and 6-5 reveal that utilization of the most efficient candidate control systems will result in total new source emission reductions of 95 percent beyond that required by typical state implementation

Table 6-3. NEW SOURCE EMISSIONS UNDER ALTERNATIVE CONTROLS (Tons Per Year)

Process	Alternative Control System											
	fabric filter high energy scrubber high efficiency ESP				medium energy scrubber ESP				Under any control meeting typical SIP regulations[a]			
	Years After Imposition of Control Alternative											
	1	5	10	20	1	5	10	20	1	5	10	20
Drying	103	538	1,156	2,717	257	1,345	2,890	6,793	670	3,497	7,514	17,660
Calcining	43	225	486	1,139	154	790	1,693	3,975	251	1,287	2,759	6,478
Grinding	15	81	173	408	23	122	260	612	2,200	11,880	25,373	59,840
Ground Rock Handling	14	76	161	381	21	114	243	571	500	2,714	5,750	13,607
Totals	175	920	1,976	4,645	455	2,371	5,086	11,951	3,621	19,378	41,396	97,585

[a] Based on typical emissions regulations as given in Table 3-6.

Table 6-4. REDUCTION OF EMISSIONS FROM SIP LEVELS WHEN ALTERNATIVE CONTROLS ARE APPLIED (lb/ton)

Source	Alternative Control System	
	Fabric filter High energy scrubber High efficiency	Medium energy scrubber ESP
Dryer	0.22	0.16
Calciner	0.73	0.34
Grinder	0.87	0.87
Ground Rock Handling	0.19	0.19

regulations. Utilization of the less efficient medium energy scrubber or ESP results in total new source emission reductions of 87 percent beyond the state implementation requirements. In addition, variation between the levels of control has the greatest incremental impact on the process of drying, and very little impact on grinding and ground rock handling as can be seen in Table 6-5.

6.2.1.5 Atmospheric Dispersion Modelling[11] - An atmospheric dispersion model was used to assess the level of the ambient concentration which results from emissions from phosphate rock processing plants. The modelling considered estimates over 24-hour and annual averaging periods for particulates. All pollutants are assumed to display the dispersion behavior of non-reactive gases. The estimated pollutant concentrations are based on the application of state-of-the-art modelling techniques, which implies a realiability of the estimates to within about a factor of two.

Table 6-5. REDUCTION IN ANNUAL EMISSIONS FOR VARIOUS CONTROL ALTERNATIVES

Process	Alternative Control System							
	fabric filter high energy scrubber high efficiency ESP				medium energy scrubber ESP			
	Years After Imposition of Control Alternative on New Sources							
	1	5	10	20	1	5	10	20
Drying	567	2,959	6,358	14,943	413	2,152	4,624	10,867
Calcining	208	1,062	2,273	5,339	97	497	1,066	2,503
Grinding	2,185	11,799	25,200	59,432	2,177	11,758	25,113	59,228
Ground Rock Handling	486	2,638	5,589	13,226	479	2,600	5,507	13,036
Totals	3,446	18,458	39,420	92,940	3,166	16,827	36,310	85,634

As shown in Table 6-6, eight combinations of process and size were examined: 70 and 25 tons per hour (TPH) calcining operations, 300 and 50 TPH drying operations, and 100 and 20 TPH grinding operation. The levels of control achieved by the various control alternatives and the control level achieved by typical state implementation regulations were examined within each combination.

The following assumptions are applied in the analytical approach:

1. There are no significant seasonal or hourly variations in emission rates for these plants.

2. The plants are located in flat or gently rolling terrain. In restrictive terrain, the dispersion of effluents could be more impaired, resulting in higher ambient concentration levels.

3. The meteorological regime is unfavorable to the dispersion of effluents. The effect of this is to introduce an element of conservatism into the analysis.

A stack not sufficiently taller than surrounding structures is an unfavorable feature of all 18 prototype plants analyzed (EXCEPTION: the three 100 TPH grinding facilities). This causes aerodynamic complications which can seriously interfere with the rise of the effluent plume, thereby producing significantly higher ground-level concentrations. The physical dimensions and other dispersion-related plant characteristics associated with these designs are summarized in Table 6-7. Note that 18 "plants" are enumerated.

Table 6-6. EMISSION SOURCE CHARACTERISTICS OF TYPICAL PHOSPHATE ROCK PROCESSING PLANTS

Process	Production Rate (TPH)	Plant Number	Stack Height (m)	Stack Diameter (m)	Stack Temp. (°K)	Stack Velocity (m/s)	Building Height (m)	Particulate Emission Rate (gm/s)	Level of Control[a]
Calcining	70	1	15.2	0.70	334	42.9	10	1.3	1
	70	2	15.2	0.70	334	42.9	10	4.8	2
	70	3	15.2	0.70	334	42.9	10	7.8	3
	25	4	15.2	0.70	334	42.9	10	0.5	1
	25	5	15.2	0.70	334	42.9	10	1.7	2
	25	6	15.2	0.70	334	42.9	10	2.8	3
Drying	300	7	21.3	2.13	339	9.10	15	1.5	1
	300	8	21.3	2.13	339	9.10	15	3.8	2
	300	9	21.3	2.13	339	9.10	15	9.8	3
	50	10	15.2	0.70	334	42.9	10	0.25	1
	50	11	15.2	0.70	334	42.9	10	0.63	2
	50	12	15.2	0.70	334	42.9	10	1.6	3
Grinding	100	13	30.5	0.91	322	97.3	15	0.08	1
	100	14	30.5	0.91	322	97.3	15	0.11	2
	100	15	30.5	0.91	322	97.3	15	11.1	3
	20	16	21.3	0.61	322	12.3	15	0.02	1
	20	17	21.3	0.61	322	12.3	15	0.02	2
	20	18	21.3	0.61	322	12.3	15	2.2	3

[a] Level 1 control corresponds to high efficiency scrubber, ESP, and fabric filter. Level 2 corresponds to medium energy scrubber and ESP. Level 3 corresponds to emissions permitted under typical state implementation regulations.

The dispersion model used to analyze this plant is the single source model (JMHCRD-1) developed by EPA's Meteorology Laboratory. A summary description of this model is given in Appendix F.1.

The model is programmed to use a previously determined set of dispersion conditions derived from the basic meteorological data for each hour of the given year. The calculations simulate the interactions between the plant characteristics and these dispersion conditions to produce a dispersion pattern for each hour. These computations are performed for each point in an array of 180 receptors encircling the plant. Cumulative averages are calculated at each of the receptors for any number of hours. In the case of phosphate rock processing, the averaging periods of interest are 1 hour, 24 hours, and annual.

The phosphate rock processing plants were modelled with the aerodynamic-effects version of JMHCRD-1 (Appendix F.2). These effects were found to be critical for the 300 TPH drying plant and the 20 TPH grinding plant. The effects were noticeable in most of the other phosphate rock processing cases examined, but were less significant. The exceptions to this were the 100 TPH grinding facilities where no significant aerodynamic effects were noted.

Preliminary analyses indicated that the critical meteorological conditions (i.e., those giving rise to maximum short-term impact) varied with the different prototype plant designs. These may be categorized into two general sets of conditions, namely, those characterized by high wind speeds under slightly unstable conditions and those characterized by low wind speeds under highly unstable atmospheric conditions. Within each of these two general classes, there was further differentiation exhibited by wind speed. In addition, if such conditions occur frequently at a given location, especially if they can be combined with a high directional bias in the wind, then longer-term impact (e.g., 24-hour and annual) will also tend to be a maximum.

The maximum estimated concentrations for the various averaging periods associated with each pollutant from each phosphate rock process are given in Table 6-7.

As expected, the highest concentrations are generated by sources which are emitting at the ceiling rates permitted by typical state implementation regulations. The maximum 24 hour average particulate concentration resulting from a 70 TPH calciner is estimated to occur .3 km from the 15.2 m stack, and would be about 89 $\mu g/m^3$ when the calciner is regulated by state implementation regulations. When the calciner emissions are controlled by fabric filters, high energy scrubbers, or high efficiency electrostatic precipitators, the maximum resulting 24 hour average particulate concentration is expected to be 14 $\mu g/m^3$. The concentration of particulate matter resulting from smaller calciners (25 TPH) is proportional to the decrease in capacity for the typical calciner plants investigated.

The 300 TPH drying process plants have higher concentrations than the 50 TPH plants with respect to their emission rates. For example, although Plants 7 and 12 have nearly equivalent emission rates, the 300 TPH plant (Plant 7) has much higher maximum concentrations as well as slightly shorter distances to maximum annual concentrations. These high concentrations at

Table 6-7. ESTIMATED GROUND-LEVEL CONCENTRATIONS OF TOTAL SUSPENDED PARTICULATES DUE TO EMISSIONS FROM PHOSPHATE ROCK PROCESSING PLANTS

Process	Production Rate (TPH)	Plant Number	Annual Concentration (μg/m³)	Annual Dist. (km)	24-Hour Concentration (μg/m³)	24-Hour Dist. (km)	Emission Rate (gm/s)	Level of Control[a]
Calcining	70	1	1.3	0.6	14	0.3	1.3	1
	70	2	5.0	0.6	55	0.3	4.8	2
	70	3	8.1	2.5	89	0.3	7.8	3
	25	4	0.5	0.6	6	0.3	.5	1
	25	5	1.8	0.6	19	0.3	1.7	2
	25	6	3.0	2.5	31	0.3	2.8	3
Drying	300	7	18	0.3	88	0.3	1.5	1
	300	8	46	0.3	223	0.3	3.5	2
	300	9	119	0.3	575	0.3	9.8	3
	50	10	0.3	0.6	3	0.3	0.25	1
	50	11	0.7	0.6	7	0.3	0.63	2
	50	12	1.8	0.6	18	0.3	1.6	3
Grinding	100	13	<1	1.0	<1	1.0	0.08	1
	100	14	<1	1.0	<1	1.0	0.11	2
	100	15	3	1.0	16	1.0	11.1	3
	20	16	<1	0.3	1	0.3	0.02	1
	20	17	1	0.3	1	0.3	0.02	2
	20	18	16	0.3	132	0.3	2.2	3

[a] Level 1 control corresponds to high efficiency scrubber, ESP, and fabric filter. Level 2 corresponds to medium energy scrubber and ESP. Level 3 corresponds to emissions permitted under typical state implementation regulations.

extremely close-in distances for the 300 TPH drying process plants are due to severe aerodynamic complications on the plume rise. Emissions from the 50 TPH plants do not experience these aerodynamic conditions since they have a much higher exit velocity than the 300 TPH plants. Based on the modelling results in Table 6-7, ambient concentrations of particulate matter are expected to violate both the annual and 24 hour National Ambient Air Quality Standards near a 300 TPH dryer which is controlled to comply with typical state implementation regulations. Substantial concentrations would also be expected when medium energy scrubbers or electrostatic precipitators are used as control. It is estimated that utilization of fabric filters or controls of equivalent efficiency (high energy scrubber and high efficiency ESP) would reduce ambient concentrations to acceptable levels.

The highest particulate concentrations from the grinding process plants are produced by Plant 18 and are due partly to a relatively high emission rate, but primarily to aerodynamic effects on plume rise. The three 20 TPH grinding process plants have relatively much higher maximum concentrations with respect to their emission rates than the 100 TPH grinding process plants. These are due to the aerodynamic effects such as downwash on plume rise, created mostly by much lower exit velocities for the 20 TPH plants. This also causes the 20 TPH maximum concentrations to be extremely close to the plants. None of the model grinder plants alone are estimated to cause violations of the ambient air standards.

6.2.2 Solid Waste Impact

None of the alternative emission control systems are expected to result in significant additional solid waste impacts beyond that experienced under enforcement of state regulations.

The solid waste from phosphate rock processing (drying, calcining, grinding and ground rock handling) consists of material that is collected in air pollution control devices. Although emissions from grinders and ground rock handling are controlled largely by using baghouses, some scrubbers are also being used. Emissions collected by baghouses should not be considered solid waste because this material is recycled. Companies do, however, recycle this material in different ways: to ground rock storage, to the grinder, directly to product, etc. Scrubbed emissions from grinding and ground rock handling are normally piped to large settling ponds which also contain solids-laden effluent from other plant processes. The incremental amount of solids added as a result of more stringent control of emissions will be negligible.

The emissions from dryers and calciners are usually collected with scrubbers, although some electrostatic precipitators are also used. The usual practice for handling the material collected in scrubbers and electrostatic precipitators, which is generally considered solid waste, is to pump it to the large settling ponds mentioned above. Data on solid waste from 10 dryers includes values ranging from 1.75 lb/ton to 16 lb/ton with an average of 8.35 lb/ton of rock processed.

The incremental impact of the alternative control systems on solid waste is presented in Table 6-8. The incremental amounts represent the additional solid waste over that which is produced when typical state regulations are enforced, assuming that all collected emissions from grinding and ground rock handling are recycled, and that those from calcining and drying are wasted. Basically, therefore, the values in Table 6-8 are the sum of annual emissions reductions for calcining and drying at new sources as presented in Table 6-5.

Considering that about 70 percent of the material in ore mined in Florida is removed as unuseful waste during beneficiation,[12] and that this amounts to over 100 million tons per year, then the additional amount of solid waste resulting from application of the control alternatives shown in Table 6-8 is insignificant.

6.2.3 Energy Impact

The energy impact of more stringent levels of control for the phosphate rock processing industry is the resulting incremental increase in energy for pollution control systems beyond that required to meet existing state standards.

Table 6-8. INCREMENTAL IMPACT OF ALTERNATIVE CONTROLS ON SOLID WASTE

(TONS/YEAR)

Control Alternatives	Years after imposition of Controls on New Sources			
	1	5	10	20
Fabric filter High energy scrubber High efficiency ESP	775	4,021	8,631	20,282
Medium energy scrubber ESP	510	2,649	5,690	13,370

The forms of energy, by process, included in the impact are electricity for dryers, calciners, grinders, pollution control equipment and ground rock handling systems and fuel for calciners and dryers. The control devices included are scrubbers (impingement, cyclonic and venturi), electrostatic precipitators (ESP's), and baghouses.

6.2.3.1 Current Energy Usage - Typical energy usages and ranges of energy usage for phosphate rock dryers and associated air pollution control devices currently being used are shown in Table 6-9. Process energy usage for dryers varies from 251,000 to 481,000 Btu/ton processed. The process fuels being used to fire the dryers are natural gas and fuel oil. Electrical usage for dryers is typically 6000 Btu/ton or approximately 1-1/4 to 2-1/2 percent of the total processing energy. Note in Table 6-9 that the energy consumption of the pollution control devices for dryers, which is entirely electrical energy, does not have a large impact on the total process and control energy consumption. The energy usage of the control devices varies from less than 1.0 percent of the total energy usage for cyclonic scrubbers to 6.8 percent for medium energy venturi scrubbers. However, of the total electrical energy consumption, cyclonic scrubbers consume about one-third of the electrical energy, and the other control devices listed which do not include baghouses consume more than one-half. Hence, control devices for dryers currently have a large impact on electrical energy only.

Energy usages reported for five fluidized-bed phosphate rock calciners range from 375,000 to 525,000 Btu/ton processed with an average of 469,000

Table 6-9. ENERGY CONSUMPTION FOR PHOSPHATE ROCK DRYERS AND ASSOCIATED CONTROL DEVICES (Typical and Range)

Dryer Type (Unit size, TPH)	Process Energy (Btu/ton		Control Device	Control Device Energy (Btu/ton)		Typical Control Device Energy	
	Range	Typical		Range	Typical	Percent of Total	Percent of Electricity
Rotary (330)		251,000	IS & ESP		5,690	2.2	58
Rotary (350)		281,000	VS		20,600	6.8	76
Fluidized Bed (165)		279,000	IS & ESP		8,900	3.1	60
Fluidized Bed (330,333)	390,000 - 469,000	443,000	CS	2,450 - 3,000	2,810	0.6	32
Rotary (186,186,187,278)	274,000 - 335,000	305,000	IS	7,775 - 9,810	8,310	2.7	59
Rotary (239) and Fluid Bed (317)	395,000 - 481,000	438,000	CS	2,690 - 3,570	3,130	0.7	31
Fluidized Bed		395,000			3,100	0.8	34

Legend:

IS	impingement scrubber
ESP	electrostatic precipitator
VS	venturi scrubber at 18 inches of water ΔP
CS	cyclonic scrubber

Btu/ton. Unfortunately, it is not possible to accurately determine from industrial data the portions of electrical energy consumed by fluidized-bed calcining and by the associated emission controls separately. However, the total electrical energy consumption is less than 2.5 percent of the total process and control energy consumption by impingement and cyclonic scrubbers and by electrostatic precipitators. When medium energy venturi scrubbers are used, the electrical energy consumption for both calcining and emission control is 15% of the total process and control energy consumption. By a comparison with electrical energy usuage for controlling emissions from dryers, it would appear that the electrical energy consumed by control systems for calcining units would be about the same percent of the total process and control energies, that is, from less than 1.0 percent of the total process and control energy consumption for cyclonic scrubbers to about 6.8 percent for medium energy venturi scrubbers.

If an average control device energy usage is assumed to be 4 percent of total electrical energy usage, as is typical for phosphate rock dryers, then the energy currently required to operate the control device would average 18,760 Btu/ton. Although no energy data are available for rotary calciners, their energy consumption is believed to be approximately 525,000 Btu/ton. This value is based on the fact that rotary calciners are normally less thermally efficient than fluidized beds.[10]

Electrical energy is the only form of energy used for phosphate rock grinders, which are usually ball mills or roller mills. The control of emissions from grinders appears to be mainly by baghouses, with some venturi scrubbers also being used. In Table 6-10 is shown the typical and the range of energy

Table 6-10. ENERGY CONSUMPTION FOR PHOSPHATE ROCK GRINDERS AND ASSOCIATED CONTROL DEVICES (Typical and Range)

Grinder Type (Unit size, TPH)	Process Energy (Btu/Ton)		Control Device	Control Device Energy (Btu/Ton)		Typical Control Device Energy Percent of Total
	Range	Typical		Range	Typical	
Roller Mill (13-65)	38,200 - 81,500	65,700	BH	1,000 - 2,450	1,495	2.2
Roller Mill (37)		118,600	VS		3,705	3.0
Ball Mill (23-68)	30,400 - 107,700	55,800	BH	1,000 - 1,825	1,275	2.2
Ball Mill* (25-220, typical 75)	15,300 - 46,600	38,219	Not Reported	Not Reported		

Legend:

* 17 installations[11]

BH baghouse
VS venturi scrubber

consumption for grinders and their respective control devices and the percent of the total process and control energy consumed by the control device. The energy requirement for the control equipment is approximately 5 percent of the total energy, and averages 1385 Btu/ton of rock processed.

Data concerning energy consumption of rock transport systems is reported by only one company. Their system consumes 43,600 Btu/ton and the associated baghouses consume 1,838 Btu/ton or 4.0 percent of the total. It is interesting to note that this company's rock transport system and associated control device consume 54 percent as much energy as its grinder and associated control device. Again, the energy impact of the control device (4 percent) is relatively minor.

6.2.3.2 Energy Increase Resulting from More Stringent Control - Table 6-11 compares energy consumption for various control alternatives with current energy usage. ESP's show a lower energy consumption than the other control devices. This is because of the low pressure drop across the device and the absence of energy requirements for pumps, shakers, compressors for pulse air cleaning, etc. The high voltage used by ESP's is usually discharged with a low average amperage and consequently does not consume much energy compared to the energy required for movement of large volumes of gases through the system. The energy required for operation of a fabric filter is about the same as for a venturi scrubber operating at 18 inches of water ΔP. Venturi scrubbers operating at 25 to 27 inches of water ΔP will consume the most energy of the systems compared, and low energy venturi scrubbers operating at about 6 inches of water ΔP will consume less energy than fabric filters and about the same as ESP's.

Table 6-11. ENERGY CONSUMPTION OF VARIOUS CONTROL ALTERNATIVES

Process	Size (TPH)	Control Device	Outlet Emissions (Gr/dscf)	Control Device Energy (Btu/ton)	Relative Increase Over Energy of Prevailing Controls,[c]
Dryer	160	Fabric Filter	(a)	5993	3.20
		ESP	(a)	2158	1.15
		High energy scrubber (ΔP=25")	.014	7771	4.17
		Medium energy scrubber (ΔP=12")	.034	3730	2.00
		Low energy scrubber (ΔP=5")	.09	1865	none
Calciner	60	Fabric Filter	(a)	10584	3.20
		ESP	(a)	3813	1.15
		High energy scrubber (ΔP=27")	.02	14860	4.50
		Medium energy scrubber (ΔP=12")	.07	6604	2.00
		Low energy scrubber (ΔP=8")	.11	3302	none
Grinder	15	Fabric Filter	(a)	1173	none[b]
		High energy scrubber (ΔP=16")	.008	1772	1.15
		Medium energy scrubber (ΔP=12")	.012	1062	-1.10

[a] The energy usage of the fabric filter and ESP's will be about the same for all control

[b] Since almost all phosphate rock grinders are currently controlled by fabric filters, no increase in energy consumption is expected for continued use of this control device.

[c] Ratio of energy used by control device to energy used by prevailing control. A negative number indicates energy savings.

Comparison of the control system energy estimates in Table 6-11 with the prevailing energy consumption figures in Table 6-9 suggests that control devices for calciners and most dryers will operate with less energy than current control devices regardless of the control option chosen. This is not likely, and is probably the result of comparing energy estimates derived from two different information sources. The current energy consumption figures were obtained from owners and operators of calciners, and the projected energy requirements for the various control levels were obtained from designers of the control equipment. However, the relative comparisons of design energy between the different systems are believed to be accurate.

6.2.3.3 Summary of Energy Impact - The energy impact resulting from more stringent levels of control for phosphate rock processing will be on electrical energy only and will depend on the type of control alternative that is used. The overall increase in energy requirements for any affected facility over that being consumed by the process and existing control devices under state regulations will be less than 8 percent for even the most energy - intensive control alternatives.

The data in Table 6-11 clearly illustrate that the energy impact will be more adverse for venturi scrubbers than for the other control devices. Relative to the prevailing controls employed to meet state regulations for dryers and calciners (low energy wet scrubbers which operate at about 6 inches of ΔP), it is expected that more stringent emission regulations will result in an 8 percent increase in total process energy requirements if high energy venturi scrubbers are used, approximately no change in energy requirements if ESP's are used, and about a 5 percent increase when baghouses are used.

Minimal actual energy impact is expected for controlling emissions from grinding and ground rock materials handling to the more stringent levels of control discussed in this chapter. The reason for this is that the emissions from these processes are currently being controlled in a number of plants with baghouses. If new sources within the industry use an alternative control device other than the baghouse, the overall process energy requirements will increase or decrease slightly depending on the type of control alternative used (i.e., scrubber of ESP).

6.2.4 Water Impact

Promulgation of Federal standards of performance for the phosphate rock processing industry will have little additional impact on water pollution beyond the impact resulting from compliance with state regulations. It is not possible to define the exact nature of the water impact associated with the control of emissions from phosphate rock processing because the amount of wastewater generated is so highly influenced by the type and application of control systems and because any wastewaters from these operations are normally combined with other wastewaters prior to treatment, recycling and/or discharge. However, the absolute water impact from phosphate rock processing is believed to be minor compared with those from phosphate rock beneficiation and from further processing operations on phosphate rock, such as phosphoric acid production.

Currently the only potential sources of water pollution from phosphate rock processing are waters from scrubbing of emissions, primarily from drying and calcining operations. Regardless of the exact source of waste waters from phosphate rock processing, the amount of water used is relatively small compared with the amount of water used for beneficiation. About 10,000 gallons per ton of product is used for beneficiation,[15] whereas 250 to 350 gallons of water per ton of processed rock is typically used to scrub emissions from drying.

Treatment of waste waters from phosphate rock processing normally consists of gravity separation in ponds which also contain waste waters from beneficiation and/or phosphoric acid production. Occasionally the overflow from these ponds is treated by addition of floculating agents and pH adjustment. Wastewaters from rock processing constitute a negligible addition to these ponds.

Deposition of the overflow waters from the settling poinds is dependent upon a number of factors. These include:

- the amount recycled;
- rainfall, (total and frequency);
- surface runoff;
- evaporative losses;
- available pond acreage.

In the western states where evaporative losses are a major factor, the entire overflow from the ponds is usually recycled and accounts for 65 percent or greater of the process water. In the eastern states, evaporative losses normally do not offset the effect of precipitation. Hence part of the overflow from the ponds is intermittently or continuously discharged to receiving bodies of water; the remaining portion, 60 to 90 percent, is recycled.[15]

6.2.5 Radiation Impact

The pollutants contained in the treatment waters can encompass not only the recognized parameters such as suspended solids, high acidity, fluorides, and phosphates, but also radiochemical pollutants (e.g., radium-226).[16] The source of the radiochemical pollution problem is the widely acknowledged presence of uranium in phosphate rock in the range of 0.1 to 0.4 pounds per ton of rock. Discharge or failure of the holding ponds described above (6.2.4) could therefore constitute a major pollution problem to the aquatic environment of receiving streams; likewise, seepage of these waters into aquifers could contaminate drinking waters. Sampling of recycled water reportedly has indicated that such waters contain 90 to 100 picocuries per liter of radiochemical pollutants[17] - more than 3 times the Atomic Energy Commission (AEC) standard for release to an unrestricted environment within an AEC licensed plant, and 30 times the maximum permissible concentration for water. However, when the radium concentration in the water table aquifer was compared at mined and unmined Florida phosphate rock reserves, no significant differences were found.[18]

Sizeable quantities of radioactive particles have been found in solid wastes discarded from phosphate rock plants. One study analyzed for radiochemical pollutants in phosphate rock slimes (a by-product of beneficiation) and found radium-226, uranium and thorium in quantities of 45, 89, and 53 picocuries per gram, respectively.[19] Soil throughout the United States typically contains between 0.15 and 2.8 picocuries of radium-226 per gram.[20]

Recent attention has been given to the exposure to radioactivity of persons in structures built on reclaimed phosphate land. One study showed exposure of inhabitants of such structures to be up to 50 times the normal background level of radiation.[21] This exposure is about 2.5 times greater than the present federal guideline for maximum exposure of uranium miners.[22] Promulgation of regulations under the authority of the Resource Conservation and Recovery Act (RCRA) will result in controls to alleviate the potential health hazards being increased at landfills.

Air emission standards will impact on the discharge of radiochemical pollutants only to the extent that they may require a slightly greater aqueous discharge and sludge disposal (i.e., from scrubbers). However, as explained in 6.2.4, the quantity of water used for emission control devices is negligible compared to the total water usage at a phosphate rock plant. If we consider only the incremental difference between the water usage necessary to comply with existing emission regulations and the amount necessary for standards of performance likely to be proposed, the impact of standards of performance on radiochemical pollution will be negligible. Likewise, the additional amount of particulate collected and ultimately disposed as solid waste will be negligible. In fact, particulate collected by dry collection devices such as baghouses will have a positive impact on radiochemical pollution since it can be returned to product inventories rather than discarded.

6.2.6 Resource and Trade-Off Analysis

Application of the alternative control systems to control emissions from the phosphate rock processing industry to within an obtainable limit will result in minimal or no short-term versus long-term trade-offs between environmental parameters. However, their application does result in trade-offs between the environmental parameters and economics, and between environmental parameters and energy.

The use of any of the alternative control systems--ESP's, high energy venturi scrubbers, or baghouses--should not result in any short-term versus long-term trade-offs involving air quality, water pollution and solid waste generation. Basically this means that the application of any one of the control systems to meet a stringent control level will not result in any adverse short-term or long-term impact on either solid waste or water, and that use of any one of the systems can accomplish the same beneficial air impact.

A significant trade-off in controlling emission from phosphate rock grinding and materials handling exists between the irretrievable loss of product (resource) and the type of control system. Dry dust control systems allow the captured emissions to be recycled as product whereas wet control systems make this practice economically infeasible. The economic benefits of recovering collected emissions is demonstrated by the fact that most plants currently recycle emissions from the primary dry collectors and from baghouses employed in control of grinders emissions.

Environmental-economic trade-offs also exist in the choice of a control system for each of the four emission sources. For the more stringent control requirements, capital costs are greater for a baghouse than for venturi scrubbers (see Chapter 7). However, energy requirements and overall operating costs, are greater for the venturi scrubbers. Therefore, the use of the baghouse would result in long-term economic and environmental benefits.

Totally economic short-term versus long-term trade-offs exist in the application of the alternative control systems. For example, the high initial capital cost of ESP's can only be compensated for in the long-term by their low operating and maintenance costs relative to the other two alternative control systems. In the application of the venturi scrubber, there is another totally economic trade-off which is low initial cost versus high energy costs. Thus in the long-term the high-energy venturi scrubber is not the most economical control system for particulate control. Use of such a device is also a long-term commitment to greater energy consumption.

Trade-offs resulting from the use of water with the venturi scrubber and not with the other devices is not considered to be significant. The reason for this is that the quantity of water used by scrubbers is not large thus permitting the waste waters so generated to be treated by conventional methods and recycled.

6.3 ALTERNATIVE ACTION PLANS

The environmental impact of the three alternative control systems is considered a major factor for the evaluation of three alternative action plans. the three plans are: 1) the continued use of SIP regulations; 2) establishing more stringent levels of control for new sources and, 3) delaying the promulgation of standards of performance in anticipation of being able to establish more stringent control in the future.

6.3.1 Continued Use of SIP Regulations

From a technical and economic standpoint, continued use of SIP regulations for new sources is unwarranted. This is because application of any of the three alternative control systems--ESP's, scrubbers, and baghouses--are capable of better control than specified by the SIP regulations. The corresponding emissions reductions over the SIP's for typical-sized new sources is presented in Table 6-5.

6.3.2 Establishing New Levels of Control for New Sources

A relative ranking of environmental impacts for the alternative control systems is shown in Table 6-12. Number one was used in the ranking to indicate the least adverse impact, and succeeding numbers were used to indicate a greater degree of adverse impact. Wherever possible quantitative information was used in ranking (e.g., particulate control limit); otherwise best engineering judgements were made.

Control of emissions with ESP's and baghouses produced minimum impacts to water, solid waste and energy. Actually, these two control devices have no impact on water and allow collected particulate matter to be recycled. This minimizes solid waste, conserves a resource, and requires

Table 6-12. RANKING OF IMPACTS FOR THE ALTERNATIVE CONTROL SYSTEMS

Control System	Impacts				
	Air	Water	Solid Waste	Energy	Radiation
High-energy Venturi scrubber	1	3	3	3	3
High efficiency ESP	1	1	1	1	1
Baghouse	1	1	1	2	1
Medium energy scrubber	2	2	2	2	2
ESP	2	1	1	1	1

far less energy for operation than does a venturi scrubber. Application of venturi scrubbers to control emissions to the same degree as baghouses will result in a significant impact on energy, a negligible impact on solid waste and water, and will not permit the economic recovery of particulate matter.

6.3.3 Delaying the Establishment of Standards of Performance

If establishment of standards of performance is delayed for about five years, EPA will be in a better position to evaluate the technical and economic feasibility of wet grinding. If proved feasible, wet-grinding would enable the Agency to promulgate standards which would disallow all particulate emissions from phosphate rock drying and grinding of low organic ores (about 75 percent of the ores currently mined). However, for the following reasons, delaying of the standards is not recommended:

1. Over 36,000 tons of avoidable particulates would be emitted from existing plants over the next five years. This can be seen from the interpolation of the annual emissions reduction data given in Table 6-5.
2. The emissions data presented in Appendix C would be out-dated and no longer valid. This would, at great expense to the taxpayers, necessitate a new engineering program to evaluate the level of control attainable at that time.
3. Prompt institution of stringent standards will make wet-grinding even more economically attractive than it is now. This will serve to hasten industry's development of the process.

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7. ECONOMIC IMPACT

7.1 PHOSPHATE ROCK INDUSTRY ECONOMIC PROFILE

7.1.1 Industry Structure

Table 7-1 shows phosphate rock producing companies, plants, and capacities The industry consists of 20 firms which are currently mining phosphate rock at 31 locations. Another five mines are expected to be operational by 1983, and four others have been planned with indefinite start-up dates. Most firms have mining operations and rock processing plants at the same location, while a few companies mine in several areas and ship the rock to a central processing plant. Total industry capacity in January 1978 is estimated at 57.9 million metric tons per year.

The southeastern U.S. is the center of the domestic phosphate rock industry, with Florida, North Carolina, and Tennessee having over 90 percent of the domestic rock capacity (see Table 7-2). Florida, with approximately 78 percent of 1978 domestic capacity, dominates the U.S. industry and is the world's largest phosphate rock producing area. Most of these plants are located around Polk and Hillsborough counties in Central Florida, with expansion taking place in Hardee and Manatee counties. Hamilton county, located in North Florida, is the other phosphate rock producing area.

Tennessee's phosphate rock industry, located in the middle of the State, has declined in importance over the last several years and is now the least important rock producing area in the country. The Tennessee Valley Authority and two private corporations have discontinued mining in Tennessee, and no new plant expansion is planned.

North Carolina possesses a rich phosphate rock deposit in Beaufort County along the Pamlico River. Texasgulf, the only company currently exploiting

Table 7-1. PHOSPHATE ROCK PRODUCERS AND PLANT CAPACITIES[1,3]

	1967	1977	% Increase 1967-77	% of U.S. Total 1977
International Minerals and Chemicals Bonnie, Florida Kingsford, Florida Noralyn, Florida	8,618	11,340	32	20.5
Agrico Chemical Co. (Williams) Pierce, Florida Ft. Green, Florida	5,443	8,618	58	15.6
Occidental Agricultural Chemicals White Springs, Florida	1,905	2,722	43	4.9
Mobile Chemical Nichols, Florida Fort Meade, Florida	3,084	4,264	38	7.7
Brewster Phosphate Brewster, Florida Bradley, Florida		3,175		5.7
J. R. Simplot Ft. Hall, Idaho	1,814	1,814	-	3.3
U. S. Steel-Agri-Chem, Inc. Ft. Meade, Florida	3,257	1,814	-44	3.3
Gardinier Ft. Meade, Florida	-	1,966		3.6
Monsanto Industrial Chemical Co. Columbia, Tennessee Henry, Idaho	1,905	1,814	-5	3.3
Cominco-American Garrison, Montana	680	249	-63	0.5
Texasgulf Aurora, North Carolina	3,175	4,536	43	8.2
Swift Chemical Bartow, Florida	2,903	2,903	-	5.3

	1967	1977	% Increase 1967-77	% of U.S. Total 1977
Stauffer Chemical Co. Mt. Pleasant, Tennessee Vernal, Utah Wooley Valley, Idaho	2,948	1,950	-34	3.5
W. R. Grace & Co. Hookers Pr, Florida Bonnie Lake, Florida Manatee Co., Florida	2,268	4,808	112	8.7
Beker Industries Dry Valley, Idaho	-	1,089		2.0
Borden Chemical Co. Teneroc, Florida Big Four, Florida	907	907		1.6
Hooker Chemical Co Columbia, Tennessee	454	454	-	0.8
Presnell Phosphate Columbia, Tennessee	454	454	-	0.8
George Relyea Garrison, Montana	91	91	-	0.2
T-A Minerals Polk City, Florida	-	454		0.8
U. S. Total	44,970	55,271	23	100.0
Top 5 Firms	23,577	33,566	42	60.7
Top 10 Firms	35,506	46,312	30	83.8

Table 7-2. PHOSPHATE ROCK PLANT CAPACITY BY REGION, 1978[35]

	Capacity (10^3 metric tons)	Percent of Total	Number of Companies	Number of Plants
Florida	45,360	78.3	11	15
North Carolina	4,536	7.8	1	1
Tennesse	2,359	4.1	4	4
Western States	5,647	9.8	6	7
Total	57,902	100.0	22	27

this resource, recently expanded plant capacity by 43 percent and has plans for further expansion. Another company has announced plans for a large operation in Washington, North Carolina.

The western phosphate rock industry is located in eastern Idaho, northern Utah, western Wyoming, and southern Montana. This area accounts for almost six million metric tons per year of the U.S. capacity, or about 10 percent. Six companies currently operate seven mines and six processing plants.

The U.S. industry is relatively concentrated as the 10 largest producers control about 84 percent of the capacity. The two largest companies control over 34 percent. In the Florida region, two firms have nearly 44 percent of the State's capacity, while the five largest companies control over 70 percent.

There exists a great deal of vertical integration in the industry. As Table 7-3 indicates, only three phosphate rock producers do not also produce phosphate fertilizer products.[1,3,4] In many cases, the rock producers also have their fertilizer facilities at the same location as the mine or rock processing plant. Four producers use their phosphate rock to produce elemental phosphorus at the mining site and at other locations.

U.S. companies producing phosphate rock own a sizable portion of the domestic phosphate fertilizer capacity. As Table 7-4 indicates, the U.S. rock producers control from 60 to 71 percent of the domestic phosphate fertilizer capacity.[1,3,35] The domestic rock producers also control over 74 percent of the U.S. elemental phosphorus capacity.[4]

7.1.2 1977 Production of Phosphate Rock

U.S. production of phosphate rock in 1977 amounted to nearly 46.4 million metric tons, an increase of about 5.1 percent over the 1976 production level.

Table 7-3. VERTICAL INTEGRATION IN U.S. PHOSPHATE INDUSTRY[1,3,4]

Company	Rock	WPPA	DAP	Super	TSP	Furnace	P_4
Agrico	X	X	X	X	X		
Beker	X	X	X	X	X		
Bordon	X	X		X	X		
Brewster	X		X				
Cominco	X	X	X				
Gardinier	X	X	X	X	X		
W. R. Grace	X	X	X	X	X		
Hooker	X					X	X
IMC	X	X	X	X	X		
Mobil	X	X	X			X	X
Monsanto	X					X	X
Occidental	X	X	X				
Presnell	X						
Relyea	X						
J. R. Simplot	X	X	X	X	X		
Stauffer	X	X	X	X	X		X
Swift	X						
TVA	X					X	
Texasgulf	X	X	X	X	X		
USS Agri-Chemicals	X	X	X	X	X		

Rock = Phosphate rock
WPPA = Wet Process Phosphoric Acid
DAP = Ammonium Phosphates
Super = Concentrated Superphosphoric Acid
TSP = Triple Superphosphate
Furnace = Furnace Phosphoric Acid
P4 = Elemental Phosphorus

Table 7-4. PHOSPHATE FERTILIZER CAPACITY CONTROLLED BY PHOSPHATE ROCK PRODUCERS (%)[1,3,35]

Phosphoric Acid	64
Ammonium Phosphate	61
Concentrated Superphosphoric Acid	71
Triple Superphosphate	67

The producers in Florida and North Carolina together accounted for about 86 percent of this output, or about 40.1 million tons. In 1977, production from Tennessee was near the 1976 level, well below production throughout the 1960's. Western rock production was about 4.6 million metric tons, with southeastern Idaho producing about 80 percent of the total western output.[5]

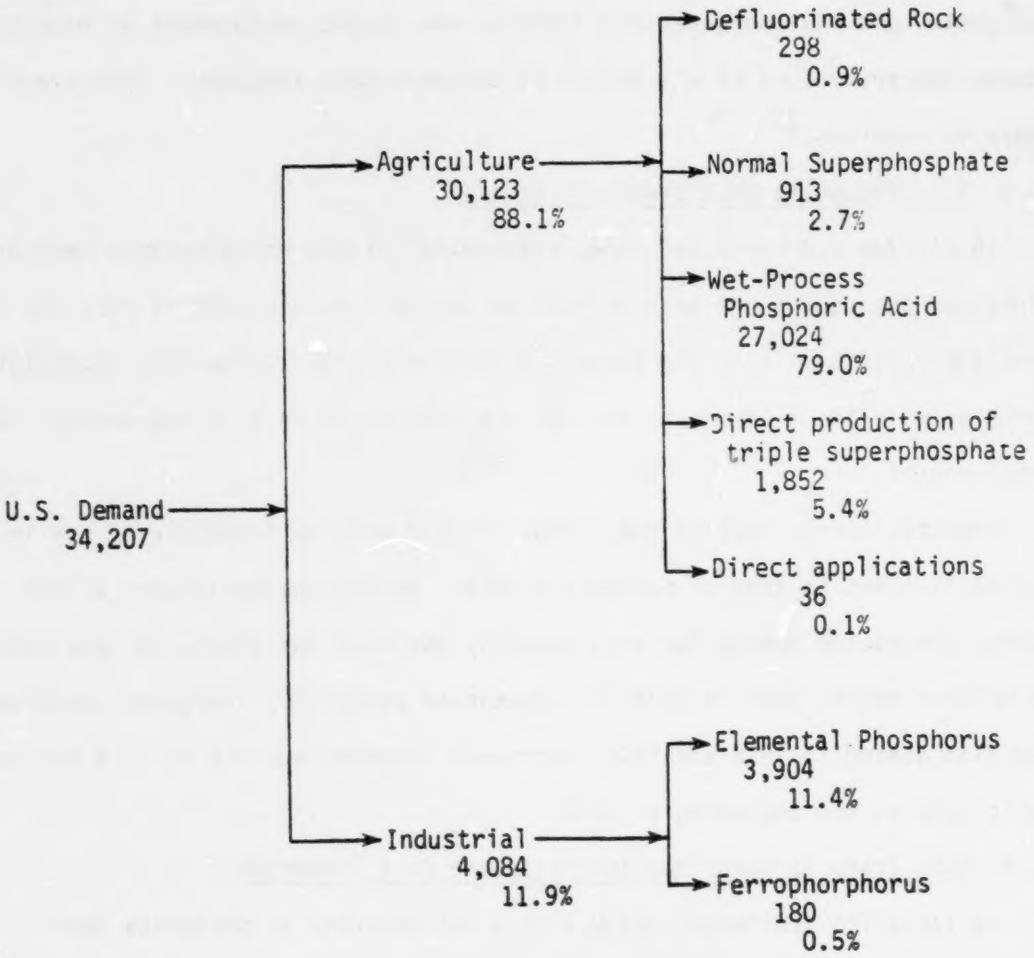
7.1.3 Consumption Pattern for Phosphate Rock

There are three principal outlets for phosphate rock produced in the U.S. First, the major portion of the phosphate rock consumed (about 50 percent) is used captively near the mine site to manufacture phosphoric acid, high-analysis fertilizers, and elemental phosphorus. Second, about 20 percent of the rock is sold to domestic fertilizer manufacturers and other producers of elemental phosphorus. The third outlet is the export market, which annually consumes roughly 30 percent of the U.S. supply. Of the domestic demand, approximately 88 percent is consumed in the manufacture of agricultural chemicals, mainly phosphoric fertilizers (see Figure 7-1). The remaining output is used in industrial chemical production, primarily elemental phosphorus, which goes into the manufacture of detergents, animal feeds, food products, metals and alloys, and a host of other products.

The Florida and North Carolina phosphate rock industries are dependent upon the domestic fertilizer market and the export market for disposing of their output. Less than 1 percent of the rock sold or used in the United States is converted into elemental phosphorus, defluorinated rock, or other minor applications. Nearly two-thirds of the annual Florida and North Carolina supply is consumed in fertilizer manufacture with the balance being exported.

All of the rock produced in Tennessee is burned in domestic electric furnaces to produce elemental phosphorus and industrial chemicals. As for Western rock, about 80 percent of the annual production is consumed domes-

Figure 7-1. Domestic Consumption Pattern for Phosphate Rock, 1977
(10^3 metric tons)


U.S. Demand
34,207
Agriculture
30,123
88.1%
Industrial
4,084
11.9%
Defluorinated Rock
298
0.9%
Normal Superphosphate
913
2.7%
Wet-Process
Phosphoric Acid
27,024
79.0%
Direct production of
triple superphosphate
1,852
5.4%
Direct applications
36
0.1%
Elemental Phosphorus
3,904
11.4%
Ferrophorphorus
180
0.5%

tically, with slightly more than one-third used in fertilizer production and the remainder used in electric furnaces to produce elemental phosphorus.[9] Roughly 20 percent of the western production is exported, mainly to Canada.[10]

One factor adversely affecting future demand for phosphate rock is the decline in the use of elemental phosphorus. About 45 percent of end use is in detergents, and environmental regulations have caused replacement or highly reduced concentrations of phosphates in the detergent industry. This trend is likely to continue.[37]

7.1.4 U.S. Phosphate Rock Inventory Stocks

In Florida and North Carolina, substantial stocks of marketable rock are maintained throughout the year so that an uninterruptible feed of rock for the fertilizer plants will be available. Mining companies in the West accumulate stocks only in the mild months so that the plants can be supplied through the winter months.

Industry stocks reached their high in 1970 with an inventory of nearly 13.2 million metric tons of marketable rock. During the early part of the decade, increasing demand for rock steadily depleted the stocks to less than 5.3 million metric tons in 1974.[11] Continued production increases, coupled with flat demand in 1975 and 1976, increased inventoried rock to 13.8 million metric tons at the beginning of 1978.

7.1.5 U.S. Trade Patterns and the Phosphate Rock Situation

As Table 7-5 indicates, the U.S is a net exporter of phosphate rock. Over 13.2 million metric tons of rock were exported in 1977, with more than 93 percent of this total coming from Florida. Western producers exported the remainder to Canada. Exports fell sharply during 1975 and 1976 as prices rose sharply and then dropped to help clear inventories after a strong year in

Table 7-5. U.S. EXPORTS AND IMPORTS OF PHOSPHATE ROCK

(10^3 metric tons)

	Exports	Imports
1964	5,782	159
1965	6,643	134
1966	8,390	161
1967	9,137	126
1968	10,976	105
1969	10,284	127
1970	10,649	123
1971	11,419	76
1972	12,950	50
1973	12,585	59
1974	12,605	165
1975	11,131	33
1976	9,433	46
1977	13,230	158

1974. In 1977, exports were up only 5 percent over 1974. Over the last several years, an increasing percentage of Florida rock has been going to the export market, where prices are generally higher. This trend is unlikely to continue indefinitely, however, as most export demand is for high grade, high quality rock. Grade refers to the percentage of bone phosphate of lime (BPL) in the rock, and quality refers to the absence of foreign materials. The quality and grade of rock being taken from existing mines in Florida are declining severely, and the remaining exploitable deposits are of low quality. This signals a long-term, gradual decline in Florida's importance in the industry,.with the slack in high quality rock supply likely to be taken up by North Carolina and Western producers.[38]

While the United States is the world's largest producer of phosphate rock, with almost 42 percent of the world production in 1976,[11] it is not the world's largest exporter. Morocco, the world's third leading rock producer, behind the United States and the Soviet Union, dominates the world's export market with 37 percent of the world's rock export shipments.[12] The U.S., on the other hand, supplies between 20 and 25 percent of the world's export shipments. As a result of its dominance and its plentiful supplies of high quality rock, Morocco, almost alone, dictates the price of phosphate rock in the export market throughout the world.[12]

In June of 1977, Beker Industries, an American fertilizer manufacturer with some phosphate production capacity of its own, announced that it had contracted to purchase a substantial quantity of rock from Morocco.[39] This was the first penetration of the U.S. market by a foreign producer, but it is unlikely that imports will account for a significant component of U.S. supply in the foreseeble future.

7.1.6 Recent Industry Performance and Prices

Since over 80 percent of the phosphate rock sold or used in the United States is consumed in the production of fertilizers, and since most of the rock exported is eventually turned into fertilizers abroad, the U.S. phosphate rock industry is naturally tied closely to the domestic and world fertilizer markets. As a result, when discussing the performance of the domestic rock industry, one is also considering the performance of the domestic and world fertilizer markets, and vice versa.

In the early to mid 1960's, world and domestic fertilizer use expanded rapidly as farmers at home and abroad responded to threats of famine facing an increasing world population. In order to feed the world from a limited amount of land, it was imperative that increasing amounts of fertilizers be used to obtain higher crop yields. With the use of fertilizers growing worldwide, the production of phosphate rock expanded, both to supply domestic needs and to satisfy the burgeoning world demand. As Table 7-6 indicates, U.S. production of phosphate rock grew from a level of 23.3 million metric tons in 1964 to 37.5 million metric tons in 1968, a compound annual growth rate of 12.6 percent.[13] The biggest jump in production came in 1966 when production increased nearly 10 million tons. Much of this increase in U.S. production during this period was due to the export market. U.S. rock exports nearly doubled from 5.8 million metric tons in 1964 to 11.0 million metric tons in 1968, a growth rate of over 17 percent annually (see Table 7-5).

The healthy growth rates experienced by the rock and fertilizer industries from the early to mid 1960's attracted new producers, mainly oil companies, into the industry and caused existing producers to expand their capacity. However, this build-up in both rock and fertilizer capacity surpassed

Table 7-6. U. S. PRODUCTION OF PHOSPHATE ROCK, 1964-77[13-15,36]

	Florida and North Carolina		Tennessee		Western States		Total U.S.
	Million Metric Tons	Percent of Total	Million Metric Tons	Percent of Total	Million Metric Tons	Percent of Total	Million Metric Tons
1964	--	--	--	--	--	--	23.3
1965	--	--	--	--	--	--	26.8
1966	--	--	--	--	--	--	35.4
1967	28.9	80.2	2.7	7.5	4.4	12.3	36.1
1968	29.9	80.0	2.9	7.7	4.6	12.3	37.5
1969	27.1	79.3	3.0	8.8	4.1	11.9	34.2
1970	28.4	80.9	2.9	8.3	3.9	11.1	35.1
1971	29.2	82.8	2.4	6.7	3.8	10.8	35.3
1972	30.9	83.6	2.0	5.4	4.2	11.3	37.0
1973	31.2	81.7	2.3	5.9	4.7	12.4	38.2
1974	33.6	81.0	2.2	5.3	5.7	13.8	41.5
1975	37.0	83.4	2.0	4.5	5.4	12.1	44.4
1976	37.3	84.4	1.6	3.7	5.3	11.9	44.2
1977	40.1	86.3	1.7	3.7	4.6	10.0	46.4

Note: Data may not add to totals because of independent rounding.

the increase in demand, resulting in overcapacity and overproduction that became evident in 1968. World demand, which for several years had been the savior of the U.S. industry, was less than had been expected, while at the same time the domestic market dropped off somewhat (see Table 7-7). Producers had relied more on estimates of what farmers theoretically needed to meet the demand for food than on projections of what they would actually buy. This resulted in the expansion that led to the massive overcapacity in the late 1960's.

From 1968 through 1971, domestic phosphate rock and fertilizer producers suffered through a recessionary period as a result of decreased demand and overcapacity. Capacity utilization during the period hovered around 60 to 70 percent, as opposed to normal levels of 80 to 90 percent. U.S. producers were not able to ease the oversupply situation by substantially increasing exports because the industry lost much of its export trade to Morocco, which was beginning to exert its influence on the world market.

Faced with weak demand, rock producers cut back production in 1969 to a level of 34.2 million metric tons, which rose only slightly to 35.1 million metric tons in 1970 (see Table 7-6).[14,15] Even with the decreased production, industry stockpiles mounted from a level of 9.0 million metric tons in 1967 to a high of 13.2 million metric tons in 1970 (see Table 7-7). Prices for phosphate rock and other fertilizer products plummeted, and fertilizer producers suffered losses in 1968 and 1969. In 1969, for example, net income (before interest and taxes) as a percent of net sales was negative 4.3 percent.[15]

Responding to the absence of profits, rock and fertilizer producers instituted heavy cost-cutting measures. Production improvements were made in new plants, uneconomical fertilizer plants were closed, four western rock mines were shut down, cheaper transportation methods were devised, and marketing activities were cut back. Because of these measures, coupled with slowly increasing demand, the fertilizer producers turned a profit for the first time in three years. Net earnings (before interest and taxes) were 0.8 percent of net sales.[17] The recovery of the industry continued in 1971 and on into 1972 as prices showed signs of firming and production approached 80 percent of capacity. In addition, inventories were decreasing and approaching normal levels (see Table 7-7).

The cyclical nature of the phosphate rock and fertilizer industries became evident in late 1972 and during 1973 as demand for phosphate products caught up with and surpassed supply. Demand for phosphate products rose faster than expected for several reasons. First, rising farm crop prices signaled farmers to use more fertilizer in order to obtain higher yields. Second, the expansion of food crop acreages at home and abroad generated an increased demand for fertilizers. Third, U.S. agricultural aid to foreign countries led to an expansion of fertilizer use in developing countries. Thus, the strong demand coupled with the decrease in capacity made it difficult for the U.S. phosphate industry to meet the demand in the domestic and export markets for both phosphate rock and fertilizers. Production of rock reached an all-time high of 38.2 million metric tons in 1973, and industry stocks reached the lowest level (6.9 million metric tons at end of year) since 1965 (see Table 7-7).[11] Production of most fertilizer products was running at 90 to 95 percent of capacity in 1973.[18]

The tight supply situation in the United States was compounded by price controls imposed by the Federal government. Phase II controls limited domestic phosphate prices to the low levels that prevailed when the industry had excess capacity. Meanwhile, there were no controls on export prices, which increased substantially because of strong foreign demand. Fertilizer prices in the export market were 30 to 50 percent higher than domestic prices.[19] As

Table 7-7. COMPONENTS AND DISTRIBUTION OF U.S. PHOSPHATE ROCK SUPPLY 1964-77[11,36]
(Thousands of metric tons)

	Components of U.S. Supply			Total U.S. Supply	Distribution of U.S. Supply			
	Domestic Mines	Imports	Stocks as of Jan. 1		Stocks as of Dec. 31	Exports	Domestic Demand	Apparent Surplus (+) Deficit (-) Supply
1964	23,328	159	4,663	28,150	5,555	5,782	16,812	+1
1965	26,746	134	5,555	32,435	5,923	6,643	19,837	+32
1966	35,420	161	5,923	41,504	9,179	8,390	24,841	-906
1967	36,079	126	9,179	45,384	9,019	9,137	25,313	+1,915
1968	37,423	105	9,019	46,547	12,649	10,976	22,985	-63
1969	34,224	127	12,649	47,000	12,426	10,284	23,164	+1,126
1970	35,144	123	12,426	47,693	13,214	10,649	24,642	-812
1971	35,277	76	13,214	48,568	10,842	11,419	25,209	+1,098
1972	37,042	50	10,842	47,933	9,526	12,950	26,794	-1,337
1973	38,226	59	9,526	47,812	6,890	12,587	28,334	+1
1974	41,446	165	6,890	48,501	5,216	12,607	31,498	-820
1975	44,362	33	5,216	49,611	7,620	11,431	31,029	-469
1976	44,180	46	7,620	51,846	12,156	9,433	31,089	-832
1977	47,256	158	12,156	59,570	13,765	13,230	34,207	-1,632

a result, the investor-owned rock and fertilizer producers directed more of their sales efforts to the attractive export market, leaving the patron-oriented cooperatives with the difficult task of filling the shortages created in the domestic market. This reversed the historical experience in which the export market absorbed any excess after the U.S. phosphate producers had supplied the domestic market. With the increased sales volume and dramatically higher overseas prices, U.S. fertilizer producers enjoyed their most profitable year in a decade in 1973.

With the mounting domestic fertilizer shortage facing the United States, the Cost of Living Council lifted price controls on fertilizer products late in 1973 with the promise that the industry would supply more fertilizer to domestic markets. With this announcement and the continued strong demand for fertilizers, domestic prices increased steadily for the remainder of 1973 and throughout 1974. By early 1974, prices for phosphate fertilizers had risen by more than 33 percent over the freeze price level, while the price for phosphate rock had risen to $9 to $23 per short ton (depending on quality) in January 1974, from $6.50 to $20.20 per short ton in January 1973.[22] In addition, discounting on list prices was just about eliminated for fertilizers. Throughout 1974 domestic and export prices continued to increase. In April 1974, U.S. rock producers were charging $22 per short ton for 70 percent BPL (bone phosphate of lime) rock, up from $12 per short ton a year earlier. By the first part of 1975 this price had risen to $35.50 per short ton; it remained constant throughout 1975.[22,23] Prices for phosphate rock on the export market were even higher, because demand was stronger abroad. In October 1974 the U.S. export price for 70 percent BPL rock was $47 per metric ton, compared with the $65 per metric ton being charged by Morocco in January 1975.[24]

This difference between the U.S. and Moroccan export prices can be explained as follows. First, the quoted prices reflect the prices received by the producer, that is, they are net of transportation costs. Second, the largest market for U.S. and Moroccan exports is Western Europe.[3] Hence, the transportation costs for Moroccan rock are much smaller than those for U.S. rock being shipped to Western Europe.[43] Because exports to Western Europe are a large proportion of total U.S. exports, the average price received by U.S. producers is lower than the price received by Moroccan exporters. The world price in late 1973 was only $15 per metric ton.[12] The export price in 1976 fell to $32.76 per metric ton and continued its decline to $25.85 per metric ton in 1977, rebounding slightly to $26.59 for the first part of 1978. Prices charged by the Moroccans also fell significantly during this period, although not to the extent of U.S. prices.[36,40]

While fertilizer and phosphate rock capacity increased only slightly in 1974, producers were encouraged by the higher prices to operate plants at maximum capacity and to keep other plants in operation that might otherwise have been closed for economic reasons. Production of phosphate rock increased about 8.4 percent in 1974 to 41.5 million metric tons. Industry stocks were decreased by 1.6 million metric tons to an all-time low of 5.2 million metric tons and export quantities remained essentially constant (see Table 7-7). Thus, the higher domestic prices removed the incentive to increase exports, so the increased U.S. supply was able to go to the domestic market. Nonetheless, the supply and demand situation remained tight in the U.S. in 1974 as fertilizer demand was boosted further by continued high prices for farm products and increased farm acreage. Farm products were selling at double the 1967 base year prices and acreage in 1974 was 10 to 20 percent above 1973 plantings.[25] Demand for phosphate fertilizer was said to be 15 percent higher than the available supply.[26]

Although production continued to increase throughout 1975 and 1976, domestic demand dropped slightly from its 1974 level and export demand fell sharply both years. The flattening in domestic demand was a result of a bad year in the fertilizer industry (1975) following the all-time high prices and production levels of 1974. Fertilizer prices came down, which helped clear surpluses, and phosphate rock prices retreated somewhat from the sharp increases of 1974. Fertilizers began to recover in 1976, but domestic use of phosphate rock failed to rise even though prices came up slightly. This was partially due to decreased production of elemental phosphorus in Tennessee and the West for nonagricultural uses.

In 1975, the world fertilizer market was also depressed and U.S. exports of phosphate rock dropped from 12.6 million metric tons in 1974 to 11.1 in 1975. This slump continued in 1976 as prices continued to fall and exports reached a 1976 low of 9.4 million metric tons, down 25 percent from 1974. The combination of production increases and softening demand permitted phosphate producers to increase their year-end inventories from a low of 5.2 million metric tons in 1974 to 12.2 million metric tons in 1976.

The fertilizer industry recovered well in 1977 and domestic demand for phosphate rock rose from 31.1 million metric tons in 1976 to 34.2 in 1977, although the average value of rock sold on the U.S. market dropped by 17 percent, to $15 per short ton. World fertilizer demand also strengthened greatly, and the closing of the large Bu Craa mine in the Spanish Sahara has helped to relieve oversupply conditions.[41] Exports rose to 13.2 million metric tons, a 40 percent increase from the previous year, and although world prices continued to fall from 1974 levels, prices were still significantly higher than those prevailing before Morocco tripled its prices in 1974.

Demand for fertilizers is expected to fall again in 1978 as U.S. farm income continues to fall. Future demand for phosphate will be greatly influenced by USDA farm programs, which determine whether the acreage under production will be cut back. The effect of these programs is expected to be neutral at best, and could entail a significant reduction in fertilizer use. It is also uncertain how much longer the trend in increased fertilizer use per acre will continue. Production of phosphate rock for the first three months of 1978 is down 3 percent from 1977, and inventories are increasing. Exports were also down, although the price has risen from $25.85 per metric ton to $26.52 per metric ton, but were reported to be picking up in April.

7.1.7 Industry Outlook and Growth Projections

Table 7-8 indicates the additional phosphate rock processing capacity of each current or future producer that is expected to come on stream by 1983. These estimates are based on announced and planned capacity expansions that could change according to future industry performance. While the total industry expansion could be less depending on the conditions, these totals are expected to be the maximum capacity available by 1983.

As indicated in Tables 7-8 and 7-9, total industry capacity in 1983 is expected to be around 72.9 million metric tons of rock per year.[1,3] This represents a net increase of 25.9 percent, or 15.0 million metric tons, over the January 1978 total. Three new firms have plans to enter the industry while about eight new mines will be opened.

According to Table 7-9, about two-fifths (6.2 million metric tons) of the absolute capacity increase will be in Florida. The expansion will represent only a 14 percent increase over January 1978 capacity, a much lower growth rate than was expected a few years ago. Two producers are phasing out mines and replacing them with operations having similar capacities. Two companies

Table 7-8. ANNOUNCED OR PLANNED U.S. PHOSPHATE ROCK CAPACITY ADDITIONS BY 1983, BY COMPANY (Thousands of metric tons per year)[1,3,42]

Company/Location	1978 Capacity	Additional or Reduced Capacity By 1983	1983 Capacity	Capacity Planned Beyond 1983
Agrico Chemical Co.				
Pierce, Florida	5,443	-	5,443	5,443
Fort Green, Florida	3,175	-	3,175	3,175
Amax-Phillips				
Manatee Co., Florida	-	3,629	3,629	3,629
Beker Industries				
Dry Valley, Idaho	1,179	181	1,361	1,361
Manatee Co., Florida	-	-	-	1,814
Borden Chemical				
Teneroc, Florida	907	-907	-	-
Big Four, Florida	-	1,089	1,089	1,089
Brewster Phosphate				
Brewster, Florida	5,715	-	5,715	5,715
CF Industries, Inc.				
Hardee City, Florida	-	1,814	1,814	1,814
Cominco-American				
Garrison, Montana	249	-	249	249
Earth Sciences (Alumet)				
Soda Springs, Idaho	-	2,268	2,268	2,268
Gardinier				
Fort Meade, Florida	1,996	-	1,996	1,996
W. R. Grace & Co.				
Bonny Lake, Florida	2,268	-2,268	-	-
Hookers Prairie, Florida	2,540	-	2,540	2,540
Manatee Co., Florida	-	2,722	2,722	2,722
Hooker Chemical				
Columbia, Tennessee	454	-	454	454

Company/Location	1978 Capacity	Additional or Reduced Capacity By 1983	1983 Capacity	Capacity Planned Beyond 1983
International Minerals & Chemicals				
North Wales, Florida	2,722		2,722	2,722
Kingsford, Florida	8,618		8,618	8,618
Polk Co., Florida	0	91	91	91
Husky Oil Tracts, Idaho	0	1,814	1,814	1,814
Miss. Chemical Corp.				
Wauchula, Florida	-	-	-	1,814
Mobil Chemical				
Nichols, Florida	1,361	-	1,361	1,361
Ft. Meade, Florida	2,903	-	2,903	2,903
Monsanto				
Columbia, Tennessee	907	-	907	907
Ballard, Idaho	907	-	907	907
North Carolina Phosphate Co.				
South Creek, N. C.	-	-	-	3,629
Occidental Agricultural Chemicals				
White Springs, Florida	2,722	-	2,722	2,722
Presnell Phosphate				
Columbia, Tennessee	454	-	454	454
George Relyea				
Garrison, Montana	91	-	91	91
J. R. Simplot				
Ft. Hall, Idaho	1,814	-	1,814	1,814
Stauffer Chemical				
Mt. Pleasant, Tennessee	544	-	544	544
Vernal, Utah	726	-	726	726
Wooley Valley, Idaho	680	-	680	680
Swift Chemical				
Bartow, Florida	2,722	-	2,722	2,722
T-A Minerals Corp.				
Polk City, Florida	454	-	454	454

Company/Location	1978 Capacity	Additional or Reduced Capacity By 1983	1983 Capacity	Capacity Planned Beyond 1983
Texasgulf, Inc. Lee Creek, N. C.	4,536	4,536	9,072	9,072
U. S. Steel-Agrichemicals Fort Meade, Florida	1,814	-	1,814	1,814
Total	57,901	14,969	72,870	80,127

Table 7-9. PHOSPHATE ROCK PLANT CAPACITY BY 1983, BY REGION[1,3,42]
(Millions of metric tons per year)

	1978 Plant Capaticy	Percent of Total	Number of Companies	Number of Locations	Additional Capacity to 1983	Percent of Total	Number of Companies	Locations opened	Locations closed	1983 Plant Capacity	Percent of Total	Number of Companies	Locations	Percent Capacity Increase 1978-83
Florida	45.4	78.4	11	14	6.2	41.3	5	5	2	51.6	70.8	14	18	13.7
North Carolina	4.5	7.8	1	1	4.5	30.0	1	1		9.1	12.5	1	1	102.2
Tennessee	2.4	4.1	4	4	--	--	--	--	--	2.4	3.	4	4	--
Western States	5.6	9.7	6	7	4.3	28.7	3	3		9.9	13.6	8	9	76.8
United States	57.9	100	20	26	15.0	100	8	8	2	72.9	100	23		25.9

just entering the industry have plans to begin production in the state by 1983, and one major producer plans to add to its capacity by opening a small Florida mine. These expansions represent 41.3 percent of the U.S. capacity increase.

In North Carolina, the only current producer has plans to double its capacity by 1983, an increase of 4.6 million metric tons. In addition, a new producer has announced plans for a 3.6 million metric ton per year plant to be opened at an undetermined time. There are no plans for expansion in any Tennessee phosphate operations. Two firms are making major expansions in Idaho, including one major producer whose operations are currently all in Florida. Another company has plans for a slight capacity increase at one of its mines.

The rate of capacity increase has slowed in recent years, and these estimates could be somewhat optimistic depending on the performance of the fertilizer and phosphate rock industries over the next few years. Several variable factors (among them the price of farm crops, price of fertilizer, crop acreage planted, and weather conditions) influence domestic demand for fertilizer. The five-year decline in farm income and the USDA farm programs will almost certainly exert a negative influence on the growth of the industry. There has also been a steady decrease in nonagricultural uses of phosphate rock over the past few years, which is likely to continue. The U.S. Bureau of Mines has projected that domestic consumption will increase by only 2.3 percent per year between now and 1985, which would put demand at 39.2 million metric tons per year in 1983 (Table 7-10).[41]

Predictions are for greater stability in world phosphate markets. It is unlikely that there will be either severe oversupply or shortage conditions between 1978 and 1985, a welcome change after the boom and bust periods of the

Table 7-10. PROJECTED PHOSPHATE DEMAND BY 1983 (Millions of metric tons)

	Domestic Demand	Export Demand	Total Production	Capacity	Capacity Utilization (%)
1977	34.2	13.2	46.4[a]	55.3[b]	84.0
1983					
High	43.3	18.8	62.1	72.9[c]	85.2
(% Growth/yr)	(4.0)	(6.0)			
Low					
(% Growth/yr)	37.4	16.3	53.7	72.9	73.7
	(1.5)	(3.5)			
Probable					
(% Growth/yr)	39.2	17.2	56.4	72.9	77.4
	(2.3)	(4.5)			

Notes:

[a] Total production does not include inventory stocks that were required to meet demand.

[b] Capacity by the end of 1974.

[c] Capacity by the end of 1980.

preceding decade. The industry also seems to be reaching a more stable price structure after the drastic hike of 1974 and steady drops of the last three years.

World demand for fertilizer is expected to grow at about 4 to 5 percent per year, and most estimates of growth in world demand for phosphate rock are close to this figure. This figure is lower than the growth experienced over the last decade, partially because developed nations which have historically purchased most of the U.S. exports are reaching the upper stage of the growth curve for fertilizer use. In addition, the rate of world population growth is declining, indirectly affecting world fertilizer consumption.

One factor that is significant in determining what share of the export market is controlled by U.S. producers is that most world demand is for high quality rock. Florida, which now controls almost all of the U.S. export market, will have an increasingly difficult time meeting quality requirements as the quality of its ore continues to decline.[38] Morocco, the world's leading phosphate rock exporter, has no problems with quality. U.S. producers will do well merely to maintain their current market share, and even this depends on pricing and production decisions by Morocco, over which they have little control.

Projections based on a probable annual growth rate of 4.5 percent put U.S. exports at 17.2 million metric tons in 1983. Using the median projections for domestic and export demand, 56.4 million metric tons of U.S. rock will be consumed in 1983 while the industry will have a capacity of 72.9 million metric tons. This indicates that the industry will have to produce at about 78 percent of capacity to meet demand. The U.S. industry has historically produced at between 80 and 90 percent of capacity and, given the projected demand range (Table 7-10), they will probably continue at this level or reduce production slightly. Current inventories are on a three-year rising trend, so it is possible there will be some cutback to reduce these inventories if demand is soft in the next few years.

On the basis of the above discussion, the majority of the new plants and planned expansions outlined in Table 7-8 will be needed by 1983 if producers wish to keep operating at normal capacity levels. It is unlikely that planned capacity will not be sufficient to keep pace with demand unless unforeseen circumstances arise. Future projections lead to the conclusion that a period of relative stability in the phosphate rock industry will exist until at least the middle of the next decade.

7.2 COST ANALYSIS OF ALTERNATIVE EMISSION CONTROL SYSTEMS

7.2.1 Introduction

As is discussed in Chapter 5, the entire phosphate rock processing operation is defined as the stationary source, for purposes of establishing standards of performance. But comprising this processing operation are four kinds of "affected facilities": dryers, calciners, grinders, and ground rock transfer systems. New source performance standards are being considered for each of these four facilities.

In the consideration of these standards it is convenient to define a model facility. Each model is of such size and process configuration as to be fairly representative of both typical new and existing facilities in the phosphate rock industry. Furthermore, to achieve the proposed new source standards, three particulate emission control systems have been studied for application to the dryer, grinder, and calciner model facilities. Emissions from most ground rock transfer systems are already controlled to a "no visible emissions" level by use of fabric filters. Thus, achieving a no visible emissions level requires no additional control cost, if a system operator follows proper operating and maintenance procedures. However, if an operator permits his system to violate these procedures, it is possible that a no visible emissions level would be exceeded, and that, to upgrade the system to this level he would need to incur additional operating costs.

In this section, costs are presented for each of the three control systems, as they are applied to the various model facilities. Incremental operating costs are also presented for the ground rock transfer system baghouses. The costs of these systems have been based on certain technical parameters associated with the model facilities, (e.g., the gas volumetric flowrates) as well as the particulate control levels under consideration. (These parameters are listed in Table 7-11). However, because these are model facility costs, they cannot be taken to reflect costs of control systems in use at existing installations. Estimating control costs at an existing installations is very difficult without first performing detailed engineering studies.

Some model facility costs have been based on data obtained from the individual phosphate rock companies through requests for information under the authority of Section 114 of the Clean Air Act.[2 to 5] Cost data have also been available from the Industrial Gas Cleaning Institute (IGCI), which, under an EPA contract, has provided information based on bids from actual vendors of control equipment.[6,7] Finally, a control equipment vendor[8] and selected literature references [9 to 13] were used to obtain the remaining information.

Two major kinds of costs have been developed herein: installed capital and total annualized costs. The installed capital cost for each control device system includes the purchased cost of the major equipment and auxiliary equipment, the cost for site preparation and installation of the equipment, and design engineering cost. No attempt has been made to include costs for research and development, possible lost production during equipment installation, or losses during startup.

In addition, two installed cost estimates have been made for each model facility control system. The first of these reflects the cost of installing the equipment at a new facility, built, as it were, "from the

Table 7-11. TECHNICAL PARAMETERS USED IN DEVELOPING CONTROL SYSTEM COSTS[a]

Parameter:		Value:	
	Calciner	Dryer	Grinder[c]
1. Stack volumetric flowrate (actual m^3/min)[b]	2,930	2,550	38
2. Stack gas temperature (^oC)	120	75	50
3. Stack gas moisture content (% by vol.)	30	30	2
4. Plant capacity (Mg/hour)	**54**	**145**	**14**
5. Operating factor (hours/year), new plant	6,270	6,570	6,460
6. Operating factor (hours/year), modified plant	4,700	6,570	6,460

[a] References 1 to 3, and Table 6-1.

[b] Calculated based on typical gas flow rates (as given in Table 6-1) and typical temperature and moisture levels assumed above.

[c] To estimate dust recovery credit from grinder baghouses, the dust concentration of grinder emissions was assumed to be 4.5 g/dsm^3 (2 gr/dscf).

ground up". The other, the modified facility or retrofit control cost, is somewhat higher, because the cost for installing a system in an existing facility is greater, due to special design considerations, more complex piping requirements, etc. Estimating this additional installation cost or retrofit penalty is difficult, since so many factors enter in, each of which is peculiar to an individual facility. However, for the sake of simplicity, a retrofit penalty equal to fifty percent of the installation cost in a new model facility has been used in this section. This penalty is added to the installed cost of the control system in the new facility to estimate the corresponding control cost in the modified facility.

The total annualized cost is comprised of three categories: the direct operating cost, the annualized capital charges, and (where applicable) the dust recovery credit. The first accounts for operating and maintenance costs, such as:

- Labor and materials needed to operate the control equipment;
- Maintenance labor and materials;
- Utilities, which include electric power, process water, and cooling water;
- Water treatment (herein, applicable to the electrostatic precipitator and venturi scrubber systems).

The annualized capital charges account for depreciation, interest, administrative overhead, property taxes, and insurance. The depreciation and interest portion is computed by use of a capital recovery factor, the value of which depends on the device operating life (10 years for the electrostatic precipitators and venturi scrubbers; 15 years for the fabric filters) and the interest rate. (An annual interest rate of 10 percent has been assumed.) Administrative overhead, taxes, and insurance have been fixed at an additional 4 percent of the installed capital cost per year.

The dust recovery credit accounts for the value of the phosphate rock dust recovered by the control equipment. (In this section the credit has only been applied to fabric filters controlling the grinder model facilities). The dust recovery credit is estimated based on an assumed value for the collected dust of $22 per megagram ($20 per ton), and an assumed dust loading of 2 gr/dscf to the inlet of the fabric filter. Other cost factors used in computing the total annualized cost appear in Table 7-12. All costs reflect first quarter 1978 prices.

The total annualized cost is then obtained simply by adding the direct operating cost to the annualized capital charges, and subtracting any dust recovery credit from the sum.

7.2.2 Cost of Alternative Control Measures

For each of the new and modified calciner and dryer facilities discussed in the Introduction, costs have been estimated for the wet electrostatic precipitator, venturi scrubber, and fabric filter control systems. Costs for venturi scrubbers and fabric filters have been developed for model grinder facilities. The costs of the alternative control systems have been computed at four alternative control levels. These levels correspond to the performance of the alternative systems at different operating designs. The greatest level of control considered is that which is achieved by the baghouse. The level reflecting least control corresponds to the performance required to meet typical state air pollution regulations.

Table 7-12. ANNUALIZED COST PARAMETERS[a]

Parameter	
1. Operating labor	\$10/man-hour
2. Maintenance labor and materials[b]	ESP's: 2.0 percent of total installed cost Wet scrubbers: 2.5 percent of total installed cost Fabric filters: 3.0 percent of total installed cost
3. Replacement parts (bags)[c]	\$7.00/m^2 (\$0.65/ft^2)
4. Electric power	\$0.03/kw-hour
5. Process water	\$0.066/thousand liters (\$0.25/thousand gal.)
6. Operating materials (ammonia)	\$3.10/m^3/min. gas flowrate (\$0.087/acfm)
7. Dust recovery credit	\$22/Mg (\$20/ton)
8. Water treatment	\$0.015/thousand liters (\$0.057/thousand gal.)
9. Depreciation and interest	Fabric filters: 13.15 percent of total installed cost. Others: 16.28 percent of total installed cost
10. Taxes, insurance and administrative charges	4.0 percent of total installed cost

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[a] References 4, 5, 7, 13, and EPA estimates.

[b] Includes bag replacement costs.

[c] Applies to fabric filter controlling ground rock transport system.

Each of these control systems consists of several pieces of equipment. First, the wet electrostatic precipitator system consists of the ESP itself, auxiliary equipment (fans, pumps, etc.) and a centrifugal scrubber precleaner. This low efficiency precleaner is installed upstream for purposes of scrubbing the corrosive gases (sulfuric acid mist, mainly) from the effluent before it enters the ESP. (These corrosive gases result from the combustion of the more commonly used high sulfur fuel oil in the calciners and dryers.) Use of a scrubber precleaner has been found to be more cost-effective than constructing the ESP from stainless steel or other corrosion-resistant materials.

Each venturi scrubber system is comprised of the scrubber itself, auxiliaries (fans, pumps, stack, etc.) and sludge disposal equipment. The disposal equipment consists of a slurry settling system and two filtering systems (one standby) to dewater the slurry product.

A dust disposal system consisting of dust hoppers, screw conveyors, and a dust storage bin is included in the cost of each fabric filter system. Since the dust is captured in the dry state, this system permits the rock to be recycled to the process. However, except for the dust captured by the grinder baghouses, the material is of such low quality that no recovery credit is taken for it. Also included in the control system cost are the fabric filter (shaker-type), a fan, and a stack.

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7.2.2.1 Calciner Model Facility

Tables 7-13 and 7-14 illustrate the new and modified calciner model facility control costs at the four alternative levels of control, for each of the three control systems discussed previously.. Note that these levels correspond to 99 to 94.5 weight percent control of the device inlet particulate loading. As stated previously, the maximum control level considered for each of the controls is that which is achieved by the baghouse, while the lowest level reflects a typical State air pollution regulation.

As discussed in Chapter 4, venturi scrubbers are the most commonly used of the three control systems, mostly because they are less sensitive to damage caused by the high temperature of the calciner exhaust. Because of this high temperature, no fabric filters are being employed by calciner operators. However, if suitable provision is made for cooling the gas stream before it reaches the filtering compartments, then fabric filters can be used. Lastly, only one calciner is now being controlled by an ESP, but 99 percent control has been obtained with it.

Since high-sulfur content fuel can be used to fire calciners, all three systems have been designed to protect against corrosive combustion gases. The ESP system employs the aforementioned centrifugal scrubber precleaner, whereas the venturi scrubber and fabric filter systems are fabricated of 316 L stainless steel--a metal that is particularly resistant to acids and acid mists.

At all control levels, in both the new and the modified facilities, the ESP system installed cost is greater than the other two systems. The installed cost of the ESP increases substantially with increasing particulate

Table 7-13. CONTROL COSTS FOR NEW CALCINER MODEL FACILITY[a]
(54 Mg/Hour Capacity)

Control Efficiency,[e] Percent	Installed Cost	Direct Operating Cost	Annualized Capital Charges	Total Annualized Cost[b,c]
Wet Electrostatic Precipitator System				
99.0 (A/V = 4.0)	$1,857,000	$205,300/yr	$376,500/yr	$582,000/yr or $1.72/Mg[d]
97.4 (A/V = 1.5)	1,191,000	192,000	241,400	433,000 or 1.28
95.5 (A/V = 0.85)	972,000	187,600	197,000	385,000 or 1.14
94.5 (A/V = 0.69)	912,000	186,400	184,900	371,000 or 1.10
Venturi Scrubber System				
99.0 (ΔP=6.6, L/G=.0016)	602,000	210,000	122,000	332,000 or 0.98
97.4 (ΔP=3.7, L/G=.0016)	602,000	165,400	122,000	287,000 or 0.85
95.5 (ΔP=2.5, L/G=.0016)	602,000	146,800	122,000	269,000 or 0.79
94.5 (ΔP=2.0, L/G=.0016)	602,000	139,300	122,000	261,000 or 0.77
Fabric Filter System				
99.0	931,000	119,500	159,700	279,000 or 0.82

[a] References 4 to 12 and 14 to 17.

[b] Rounded to the nearest thousand dollars.

[c] The sum of the figures in columns 3 and 4.

[d] The quotient of the total annualized cost and the typical production rate.

[e] The highest control efficiency is based on performance of baghouse when treating "typical" emissions streams from phosphate rock calciners (see Table 6-2). The lowest efficiency corresponds to compliance with typical state implementation regulations. Scrubbers and ESP's are assigned a range of efficiency levels which depend on the operating parameters. Operating parameters for the scrubber and ESP are in the following units: ΔP in kilopascals; L/G in cm^3/cm^3; A/V in square meters per actual cubic meters per minute.

Table 7-14. CONTROL COSTS FOR MODIFIED CALCINER MODEL FACILITY[a] (54 Mg/Hour)

Control Efficiency,[e] Percent	Installed Cost	Direct Operating Cost	Annualized Capital Charges	Total Annualized Cost[b,c]
Wet Electrostatic Precipitator System				
99.0 (A/V = 4.0)	$2,043,000	$166,900/yr	$414,300/yr	$581,000/yr or $2.29/Mg[d]
97.4 (A/V = 1.5)	1,377,000	153,600	279,200	433,000 or 1.71
95.5 (A/V = 0.85)	1,158,000	149,200	234,800	384,000 or 1.51
94.5 (A/V = 0.69)	1,098,000	148,000	222,600	371,000 or 1.46
Venturi Scrubber System				
99.0 (ΔP=6.6, L/G=.0016)	861,000	167,600	174,500	342,000 or 1.35
97.4 (ΔP=3.7, L/G=.0016)	861,000	134,200	174,500	309,000 or 1.22
95.5 (ΔP=2.5, L/G=.0016)	861,000	120,300	174,500	295,000 or 1.16
94.5 (ΔP=2.0, L/G=.0016)	861,000	114,700	174,500	289,000 or 1.14
Fabric Filter System				
99.0	1,206,000	104,800	206,800	312,000 or 1.23

[a] References 4 to 12 and 14 to 17.

[b] Rounded to the nearest thousand dollars.

[c] The sum of the figures in columns 3 and 4.

[d] The quotient of the total annualized cost and the typical production rate.

[e] The highest control efficiency is based on performance of baghouse when treating "typical" emissions streams from phosphate rock calciners (see Table 6-2). The lowest efficiency corresponds to compliance with typical state implementation regulations. Scrubbers and ESP's are assigned a range of efficiency levels which depend on the operating parameters. Operating parameters for the scrubber and ESP are in the following units: ΔP in kilopascals; L/G in cm^3/cm^3. A/V in square meters per actual cubic meters per minute.

control efficiency (see Tables 7-13 and 7-14). This occurs because the cost of the ESP unit alone (comprising nearly all of the total system cost) is primarily a function of the collecting surface area, which, in turn, depends on the system control efficiency. As the efficiency of the ESP varies from 94.5 to 99.0 percent, the ESP surface area to gas volume ratio varies from about 0.69 to 4.0 m^2/m^3 per minute (200 to 1200 ft^2/1000 ACFM). On the other hand, the costs of the centrifugal scrubber and the ESP system auxiliaries are functions of the volumetric flowrate, and hence, do not depend on the removal efficiency.

The ESP total annualized cost also varies substantially with the system control efficiency. Based on the model process weight capacity and operating factor, this cost ranges from $1.46 to $2.29 per Mg, as the efficiency goes from 94.5 percent to 99.0 percent in a modified plant.

Because control efficiency has a negligible effect on the installed cost of a venturi scrubber system, the new and modified plant capital costs are the same for each control level ($601,700 and $860,700, respectively). However, since the scrubber electric power cost is directly proportional to the scrubber pressure drop, itself a function of the control efficiency, the direct operating cost is seen to increase about 50 percent as the efficiency rises from 94.5 to 99.0 percent. Note finally, that the scrubber total annualized cost is substantially lower than the corresponding ESP system costs. It ranges from $0.77 to $1.35/Mg.

The fabric filter installed costs, though lower than the ESP costs, are significantly higher than the scrubber investment estimates. However, the annualized cost for the fabric filter is slightly less than that of the scrubber at comparable control efficiency. Lastly, it bears noting that the fabric filter cost corresponds to a single level of efficiency. Nearly all filters are designed to achieve the most stringent control level.

The relationships between total annualized costs and the various control levels are graphically illustrated in Figures 7-2 and 7-3.

7.2.2.2 Dryer Model Facility

The same inlet dust loading, moisture content, and control systems discussed for calciners also apply to the dryer model facilities. However, some of the parameters, such as the operating factor, are different (See Table 7-11).

Venturi scrubbers are also the most commonly used system for controlling dryer particulate emissions. Two operators of rock dryers employ electrostatic precipitators, one of which is a dry unit and the other, a wet ESP. The latter system includes a wet impingement scrubber upstream from the ESP, installed for corrosion protection purposes. (The design of the model plant ESP control system has been patterned after it.) As explained in Chapter 4, fabric filtration is a feasible alternative for controlling dryer particulate emissions, even though no existing installations currently employ this method.

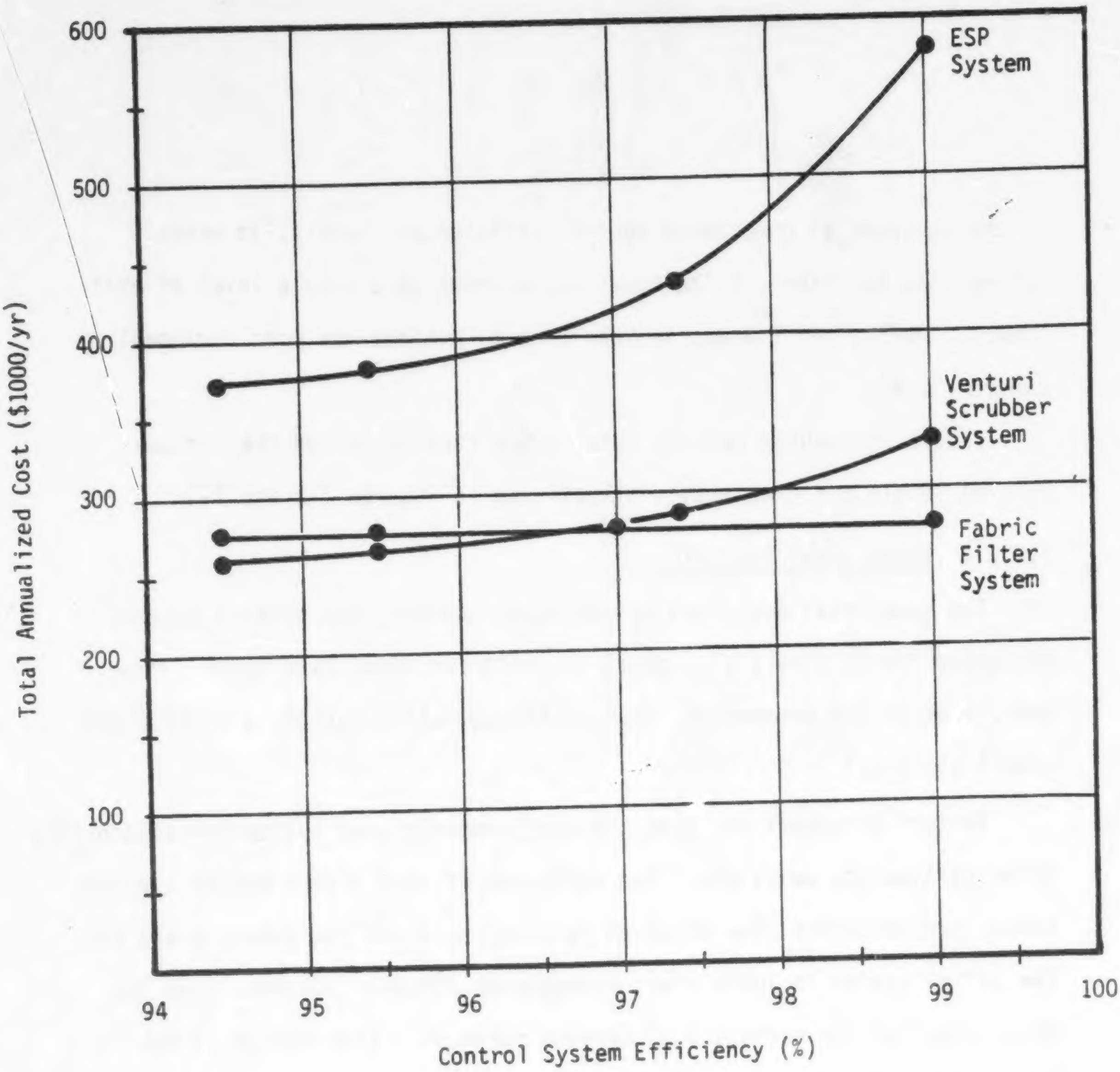

Figure 7-2. Cost curve for new calciner model facility.

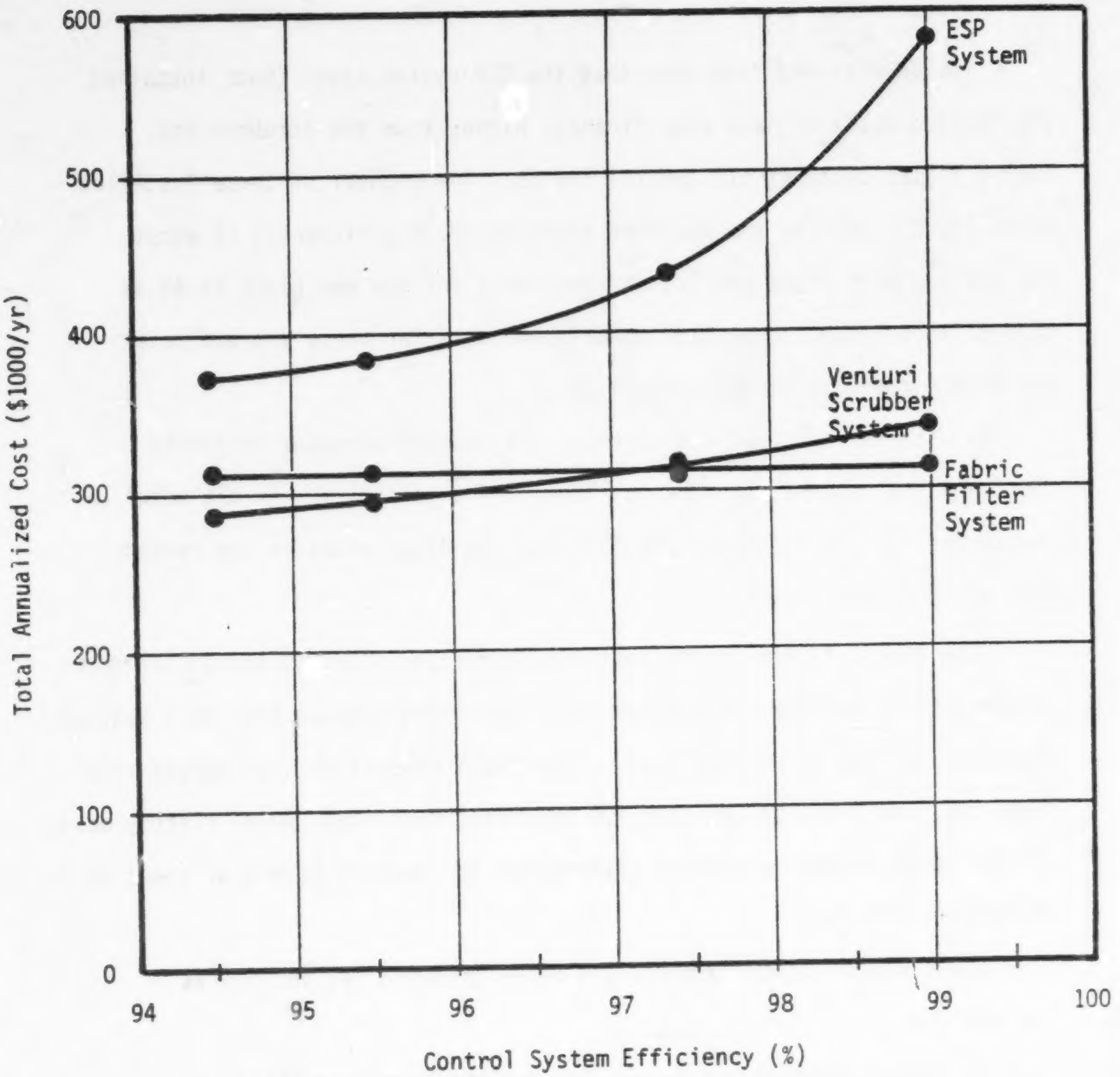

Figure 7-3. Cost curves for modified calciner model facility.

Tables 7-15 and 7-16 show that the ESP system costs (both installed and total annualized) are significantly higher than the scrubber and fabric filter costs at all control levels. The highest of these installed costs ($2,215,000 for the modified plant at 99.3% efficiency) is about two and one half times the lowest ($890,000) for the new plant at 95.5% control efficiency. The total annualized costs for these extreme cases are $0.68/Mg and $0.37/Mg, respectively.

As with the calciner application, the venturi scrubber installed costs are the same at each control level. The variability in the total annualized cost is solely attributable to the differences in the respective electric power costs.

The fabric filter system installed costs are $851,000 and $1,100,000 respectively, for the new and modified facilities--values that fall between the scrubber and ESP system costs. The total annualized cost ranges from $256,000 (new facility) to $306,000 (modified facility), which clearly makes it the least expensive control alternative for control levels of about 98.0% efficiency and more.

The costs of dryer controls are shown graphically, in Figures 7-4 and 7-5.

As stated previously, the systems employed for controlling the calciner and dryer model plants have been specially designed to resist the corrosiveness of this exhaust stream. To illustrate the differences between these costs and the costs of systems not designed with corrosion protection, Tables 7-17 and 7-18 have been constructed, respectively, for

Table 7-15. CONTROL COSTS FOR NEW DRYER MODEL FACILITY[a] (145 Mg/Hour Capacity)

Control Efficiency,[e] Percent	Installed Cost	Direct Operating Cost	Annualized Capital Charges	Total Annualized Cost[b,c]
Wet Electrostatic Precipitator System				
99.3 (A/V = 5.7)	$2,043,000	$197,600/yr	$414,200/yr	$612,000/yr or $0.64/Mg[d]
98.7 (A/V = 3.0)	1,479,000	186,300	299,900	486,000 or 0.51
97.9 (A/V = 1.9)	1,187,000	180,500	240,700	421,000 or 0.44
95.5 (A/V = 0.8)	890,000	174,600	180,500	355,000 or 0.37
Venturi Scrubber System				
99.3 (ΔP=6.2, L/G=.0016)	533,000	193,200	108,100	301,000 or 0.32
98.7 (ΔP=3.7, L/G=.0016)	533,000	159,400	108,100	267,000 or 0.28
97.9 (ΔP=2.5, L/G=.0016)	533,000	142,400	108,100	251,000 or 0.26
95.5 (ΔP=1.2, L/G=.0016)	533,000	125,500	108,100	234,000 or 0.25
Fabric Filter System				
99.3	851,000	109,700	145,900	256,000 or 0.27

[a] References 4 to 12 and 14 to 17.

[b] Rounded to the nearest thousand dollars.

[c] The sum of the figures in columes 3 and 4.

[d] The quotient of the total annualized cost and the typical production rate.

[e] The highest control efficiency is based on that attained by the baghouse when treating "typical" emissions streams from phosphate rock dryers (see Table 6-2). The lowest efficiency corresponds to compliance with typical state implementation regulations. Scrubbers and ESPs are assigned a range of efficiency levels depending on the operating parameters. Operating parameters for the scrubber and ESP are in the following units: ΔP in kilopascals; L/G in cm^3/cm^3; A/V in square meters per actual cubic meters per minute.

Table 7-16. CONTROL COSTS FOR MODIFIED DRYER MODEL FACILITY[a]
(145 Mg/Hour Capacity)

Control Efficiency,[e] Percent	Installed Cost	Direct Operating Cost	Annualized Capital Charges	Total Annualized Cost[b,c]
Wet Electrostatic Precipitator System				
99.3 (A/V = 5.7)	$2,215,000	$201,100/yr	$449,300/yr	$650,000/yr or $0.68/Mg[d]
98.7 (A/V = 3.0)	1,651,000	189,800	334,900	525,000 or 0.55
97.9 (A/V = 1.9)	1,360,000	184,000	275,700	460,000 or 0.48
95.5 (A/V = 0.8)	1,063,000	178,000	215,500	394,000 or 0.42
Venturi Scrubber System				
99.3 (ΔP=6.2, L/G=.0016)	762,000	199,000	154,500	353,000 or 0.37
98.7 (ΔP=3.7, L/G=.0016)	762,000	165,100	154,500	320,000 or 0.34
97.9 (ΔP=2.5, L/G=.0016)	762,000	148,100	154,500	303,000 or 0.32
95.5 (ΔP=1.2, L/G=.0016)	762,000	131,200	154,500	286,000 or 0.30
Fabric Filter System				
99.3	1,100,000	117,200	188,700	306,000 or 0.32

[a] References 4 to 12 and 14 to 17.

[b] Rounded to the nearest thousand dollars.

[c] The sum of the figures in columns 3 and 4.

[d] The quotient of the total annualized cost and the typical production rate.

[e] The highest control efficiency is based on that attained by the baghouse when treating "typical" emissions streams from phosphate rock dryers (see Table 6-2). The lowest efficiency corresponds to compliance with typical state implementation regulations. Scrubbers and ESPs are assigned a range of efficiency levels depending on the operating parameters. Operating parameters for the scrubber and ESP are in the following units: ΔP in kilopascals; L/G in cm^3/cm^3; A/V in square meters per actual cubic meters per minute.

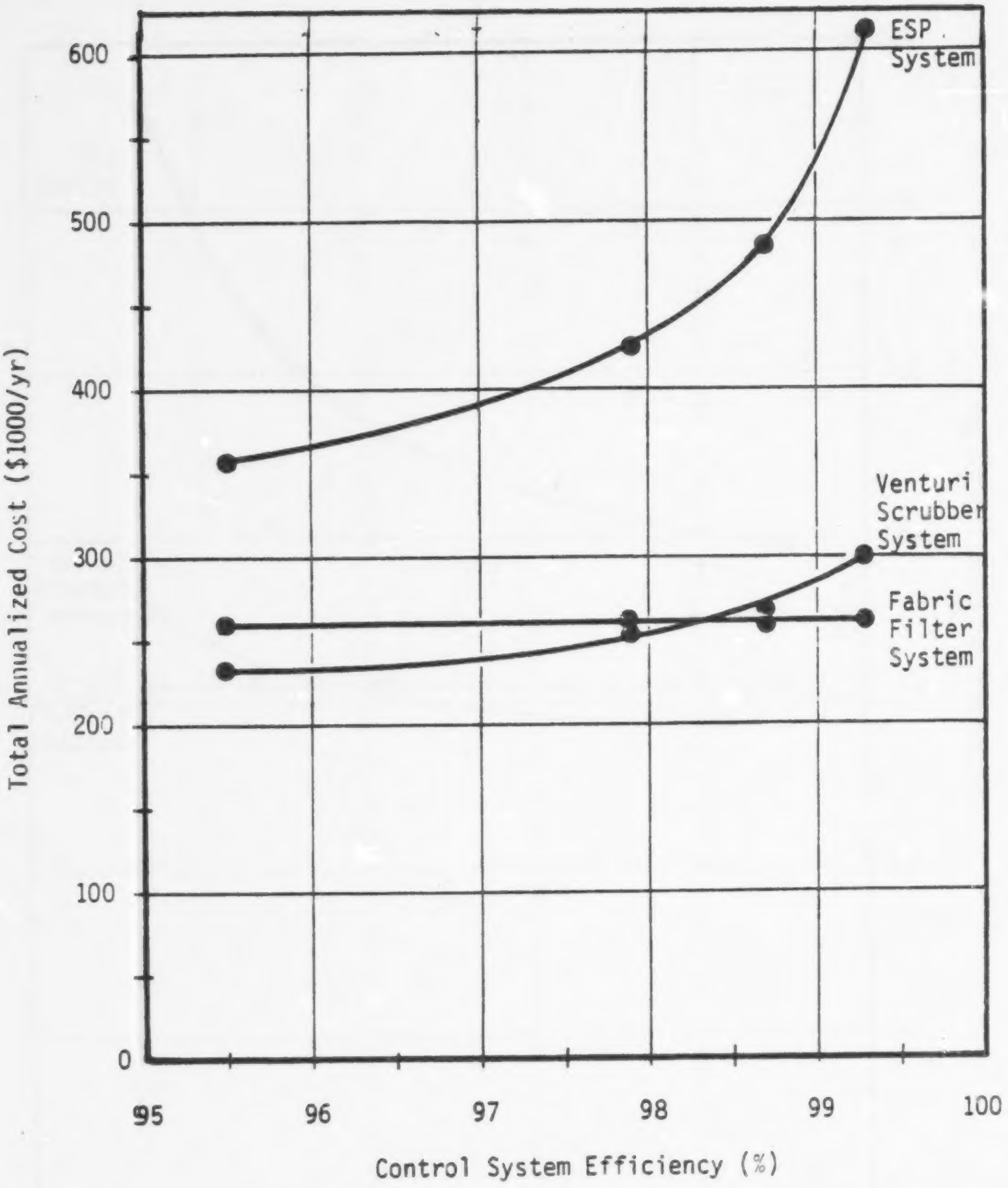

Figure 7-4. Cost curves for new dryer model facility.

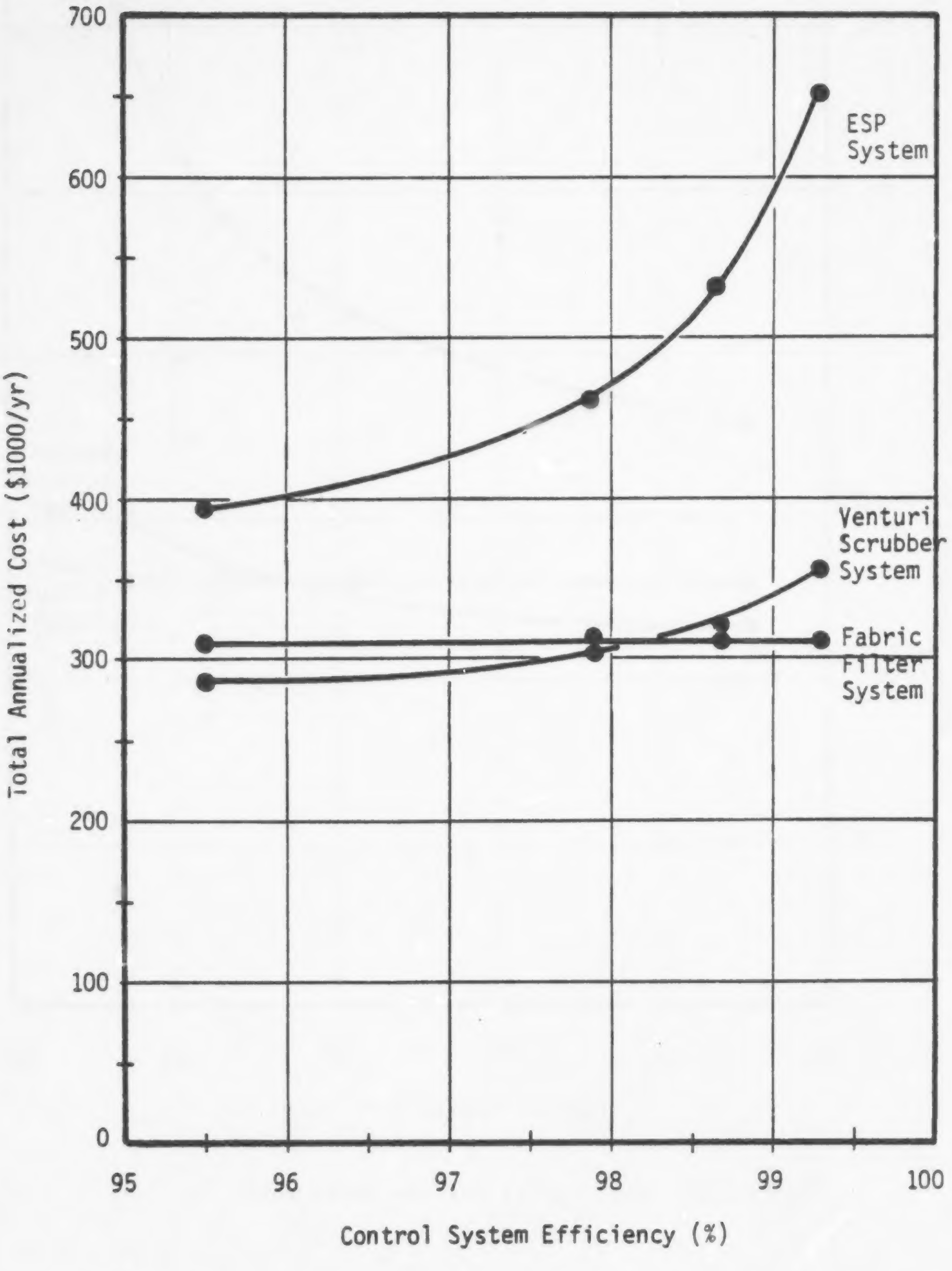

Figure 7-5. Cost curves for modified dryer model facility.

Table 7-17. TOTAL ANNUALIZED COSTS FOR CONTROL SYSTEMS, WITH AND WITHOUT CORROSION PROTECTION: NEW FACILITY INSTALLATION[a]

Control System	Control Efficiency[b] Percent	With Corrosion Protection	Without Corrosion Protection
		Calciner Model Facility	
Electrostatic Precipitator	99.0	$582,000/yr or $1.72/Mg	$476,000/yr or $1.41/Mg
	97.4	433,000 or 1.28	328,000 or 0.97
	95.5	385,000 or 1.14	279,000 or 0.82
	94.5	371,000 or 1.10	255,000 or 0.78
Venturi Scrubber	99.0	332,000 or 0.98	319,000 or 0.94
	97.4	287,000 or 0.85	275,000 or 0.81
	95.5	269,000 or 0.79	256,000 or 0.76
	94.5	261,000 or 0.77	249,000 or 0.73
Fabric Filter	99.0	279,000 or 0.82	277,000 or 0.82
		Dryer Model Facility	
Electrostatic Precipitator	99.3	$612,000 or 0.64	$510,000 or 0.54
	98.7	486,000 or 0.51	384,000 or 0.40
	97.9	421,000 or 0.44	319,000 or 0.33
	95.5	355,000 or 0.37	253,000 or 0.27
Venturi Scrubber	99.3	301,000 or 0.32	290,000 or 0.30
	98.7	267,000 or 0.28	255,000 or 0.27
	97.9	251,000 or 0.26	239,000 or 0.25
	95.5	234,000 or 0.25	222,000 or 0.23
Fabric Filter	99.3	256,000 or 0.27	254,000 or 0.27

[a] References 4 to 12 and 14 to 17.

[b] The highest control efficiency is based on performance of baghouse when treating typical emissions streams from phosphate rock dryers and calciners (see Table 6-2). Scrubbers and ESPs are assigned a range of efficiency levels which depend on the operating design (see Tables 7-13 and 7-15).

Table 7-18. TOTAL ANNUALIZED COSTS FOR CONTROL SYSTEMS, WITH AND WITHOUT CORROSION PROTECTION: MODIFIED FACILITY INSTALLATION[a]

Control System	Control Efficiency,[b] Percent	Calciner Model Facility	
		With Corrosion Protection	Without Corrosion Protection
Electrostatic Precipitator	99.0	$581,000/yr or $2.29/Mg	$470,000/yr or $1.85/Mg
	97.4	433,000 or 1.71	322,000 or 1.27
	95.5	384,000 or 1.51	273,000 or 1.08
	94.5	371,000 or 1.46	259,000 or 1.02
Venturi Scrubber	99.0	342,000 or 1.35	325,000 or 1.28
	97.4	309,000 or 1.22	292,000 or 1.15
	95.5	295,000 or 1.16	278,000 or 1.10
	94.5	289,000 or 1.14	273,000 or 1.07
Fabric Filter	99.0	312,000 or 1.23	307,000 or 1.21
		Dryer Model Facility	
Electrostatic Precipitator	99.3	$650,000 or 0.68	$532,000 or 0.56
	98.7	525,000 or 0.55	406,000 or 0.43
	97.9	460,000 or 0.48	341,000 or 0.36
	95.5	394,000 or 0.42	275,000 or 0.29
Venturi Scrubber	99.3	353,000 or 0.37	338,000 or 0.35
	98.7	320,000 or 0.34	304,000 or 0.32
	97.9	303,000 or 0.32	287,000 or 0.30
	95.5	285,000 or 0.30	270,000 or 0.28
Fabric Filter	99.3	305,000 or 0.32	302,000 or 0.32

[a] References 4 to 12 and 14 to 17.

[b] The highest control efficiency is based on performance of baghouse when treating typical emissions streams from phosphate rock dryers and calciners (see Table 6-2). Scrubbers and ESPs are assigned a range of efficiency levels which depend on the operating design (see Tables 7-13 and 7-15).

the new and modified model facilities. It is clear from both tables that the total annualized costs for ESP systems without corrosion protection are substantially lower than their counterparts. The biggest difference is due to the fact that no scrubber precleaner is required with the no protection system. In addition, the process water, water treatment, and electric power operating costs are lower.

The cost differences between designs featuring protection and no protection from corrosion, are less pronounced for the venturi scrubber and fabric filter control systems. This is because the scrubber or baghouse units designed with corrosion protection have been fabricated from 316 L stainless steel, while the normal designs have been constructed of materials such as rubber-lined carbon steel, which afford some, but not enough, protection.

7.2.2.3 Grinder Model Facility

No corrosive gases are emitted from grinding operations. Therefore, the control systems do not have any built-in corrosion protection. Thus, the venturi scrubbers and fabric filters are fabricated of carbon steel, instead of the corrosion-resistant 316 L stainless. (Because none are used to control grinders, no ESP costs have been developed.) This fact, coupled with the much lower volumetric flowrate, has resulted in substantially lower control costs for grinder facilities. The important process parameters are listed in Table 7-11.

Most commonly the vent stream from the grinders is discharged through a fabric filter, because the effluent is low, both in moisture content and in temperature. Low energy venturi scrubbers are also occasionally employed, since these devices are able to meet the SIP emission limits with relative ease.

As with the calciner and dryer models, the installed costs of the fabric filters are higher than those for the venturi scrubbers. But, as Tables 7-19 and 7-20 clearly show, the total annualized costs follow a different pattern. For the new facility the venturi scrubber annualized cost ranges from $72,000 to $74,000/year. Again, the fabric filter system annualized costs are the lower: $17,000 and $20,000, respectively, for the new and modified facilities. Finally, Figures 7-6 and 7-7 exhibit the costs for the two grinder control systems.

From the cost figures presented in this section, it seems reasonable to conclude that fabric filters are generally the least costly choice for controlling particulate emissions from calciners, dryers, and grinders. Venturi scrubbers would be a second choice, and ESP's would rate a poor third on a total annualized cost basis.

7.2.2.4 Ground Rock Transfer Systems

As stated in the Introduction, the emissions from the ground rock transfer systems are usually captured in fabric filters and recycled to the storage process. Because the ground rock is valuable, these baghouses are installed for economic reasons. Consequently, the fabric filter may be considered as standard process equipment in ground rock transfer systems. However, if a zero visible emissions standard is imposed for ground rock systems, additional resources may be necessary to prevent occasional escape of emissions (such as when a bag tears) from the baghouse compartment.

The best way to prevent baghouse upsets is to follow a strict maintenance procedure. This procedure can be further subdivided into two areas: bag replacement and general equipment maintenance.

Table 7-19. CONTROL COSTS FOR NEW GRINDER MODEL FACILITY[a]
(14 Mg/Hour Capacity)

Control Efficiency,[e] Percent	Installed Cost	Direct Operating Cost	Dust Recovery Credit	Annualized Capital Charges	Total Annualized Cost[b,c]
Venturi Scrubber System					
99.6 (ΔP=3.9, L/G=.0016)	$13,000	$70,300/yr	None	$2,600/yr	$73,000/yr or $0.81/Mg[d]
99.5 (ΔP=3.7, L/G=.0016)	13,000	70,300	None	2,600	73,000 or 0.81
99.2 (ΔP=2.5, L/G=.0016)	13,000	70,000	None	2,600	73,000 or 0.80
98.7 (ΔP=1.5, L/G=.0016)	13,000	69,800	None	2,600	72,000 or 0.80
Fabric Filter System					
99.6	59,000	8,300	$1,500	10,100	17,000 or 0.19

[a] References 7, 12 and 14 to 17.

[b] Rounded to the nearest thousand dollars.

[c] The sum of the figures in columns 3, 4, and 5.

[d] The quotient of the total annualized cost and the typical production rate.

[e] The highest control efficiency is based on performance of baghouse when treating typical emissions from grinders (see Table 6-2). Scrubbers are assigned a range of efficiency levels which depend on the operating parameters. The operating parameters for the scrubber are in the following units: ΔP in kilopascals; L/G in cm^3/cm^3.

Table 7-20. CONTROL COSTS FOR MODIFIED GRINDER MODEL FACILITY[a] (14 Mg/Hour Capacity)

Control Efficiency,[e] Percent	Installed Cost	Direct Operating Cost	Dust Recovery Credit	Annualized Capital Charges	Total Annualized Cost[b,c]
Venturi Scrubber System					
99.6 ($\Delta P=3.9$, L/G=.0016)	$19,000	$70,500/yr	None	$3,800/yr	$74,000/yr or $0.82/Mg[d]
99.5 ($\Delta P=3.7$, L/G=.0016)	19,000	70,400	None	3,800	74,000 or 0.82
99.2 ($\Delta P=2.5$, L/G=.0016)	19,000	70,100	None	3,800	74,000 or 0.82
98.7 ($\Delta P=1.5$, L/G=.0016)	19,000	69,900	None	3,800	74,000 or 0.82
Fabric Filter System					
99.6	76,000	8,800	$1,500	12,900	20,000 or 0.22

[a] References 7, 12 and 14 to 17.

[b] Rounded to the nearest thousand dollars.

[c] The sum of the figures in columns 3, 4, and 5.

[d] The quotient of the total annualized cost and the typical production rate.

[e] The highest control efficiency is based on performance of baghouse when treating typical emissions from grinders (see Table 6-2). Scrubbers are assigned a range of efficiency levels which depend on the operating parameters. The operating parameters are in the following units: ΔP in kilopascals and L/G in cm^3/cm^3.

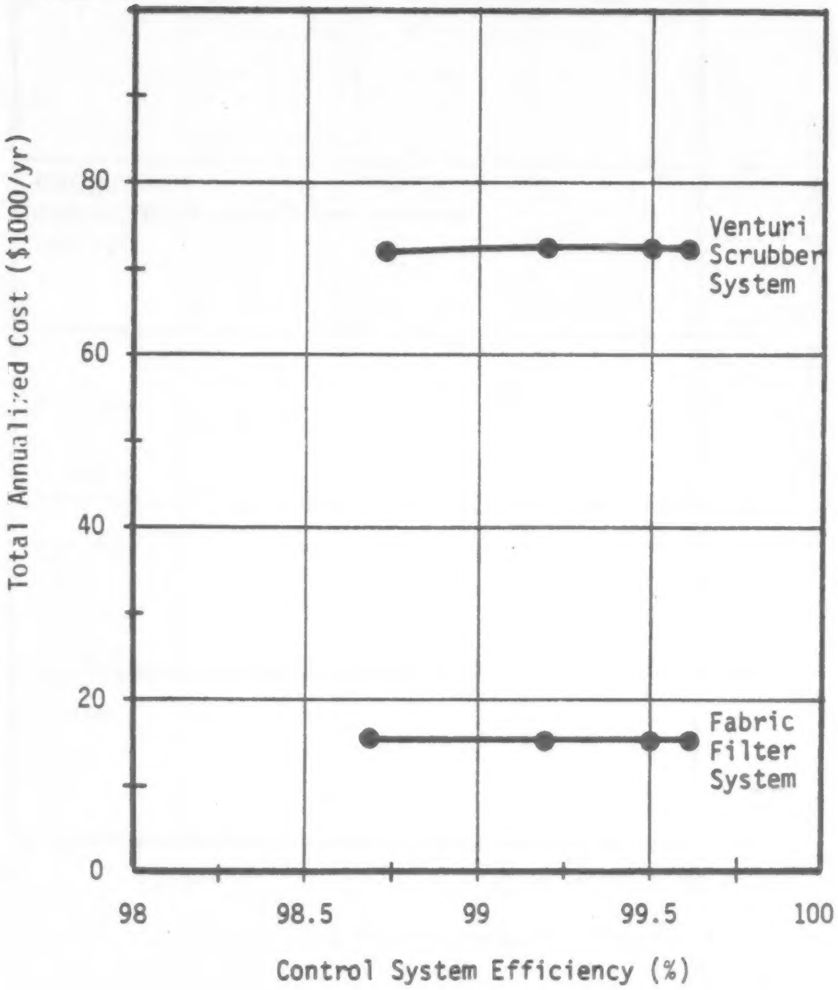

Figure 7-6. Cost curves for new grinder model facility.

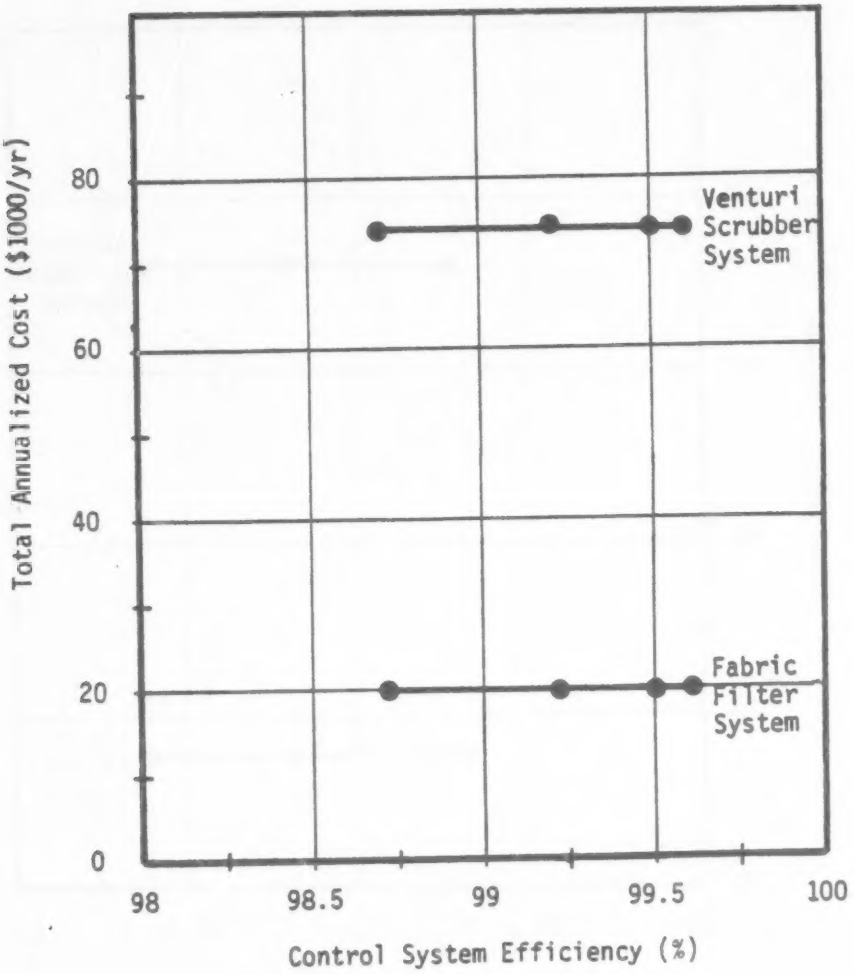

Figure 7-7. Cost curves for modified grinder model facility.

Normally, bags are replaced only when they are broken or excessively worn. The life of an individual bag is quite variable, ranging from less than 1 to 10 years.[13] However, to prevent bag failure, one source suggests changing the bags annually.[16] This would assure that a zero visible emissions limit is constantly achieved. Assuming a typical gross bag area of 14 m^2 (500 ft^2), per baghouse, and a bag cost of $\$7.00/m^2$ ($\$0.65/ft^2$), the cost of replacing polypropylene bags would be \$325/year. Labor for changing the bags would amount to 8 manhours/year, or \$80/year (based on a \$10/manhour labor rate).[16] Finally, an additional 8 manhours/year (\$80) are required for general equipment services,[16] such as lubricating the fan. Altogether, the incremental cost for maintaining a zero visible emissions limit over the normal cost of control would be approximately \$500/year.

Granted, some of these costs would be incurred under normal transfer system maintenance procedures and would not be attributable entirely to the incremental resources required to achieve a visible emissions standard. Nonetheless, to be conservative, the entire amount has been charged to maintaining a zero visible emissions limit on ground rock transfer system baghouses.

7.2.2.5 Monitoring Costs

Monitoring requirements imposed by a performance standard would inflict additional costs on phosphate rock plants. The potential requirements may include opacity monitoring equipment, rock feed measurement equipment, and equipment to monitor scrubber performance parameters. However, some of the potential monitoring requirements are already being satisfied by existing plants. At plants utilizing scrubbers to comply with existing standards, the scrubber pressure drop and liquid supply pressure are measured and continuously recorded as normal operating procedure. At calciner, dryer, and grinder facilities, the rock feed rate is normally controlled by weigh feed control equipment which also may be utilized to provide measurement of the rock feed rate (as may be required during performance testing).[19] The weighfeed device is typically utilized as process equipment to insure efficient operation of dryers, calciners, and grinders. The installed cost of rock feed control equipment is about $14,000 for a facility processing 150 tons per hour of rock, which amounts to an annualized cost (including operating and assumed maintenance costs) of about $3500 per year.[18]

The most significant potential monitoring costs would result from a visible emissions type standard. Equipment and installation costs for opacity measurement equipment are estimated to be approximately $20,000 per exhaust stack, and annual operating costs (including data recording and reduction) are estimated at about $9,000. Based on a 10 percent annual interest rate (plus an additional 4 percent for administrative overhead and taxes) and a 15 year operating life, the annualized cost of an opacity monitoring system would be about $12,500 per year. This cost is relatively minor compared to the total annualized cost of those facility emission control systems which are ducted to the common monitored stack.

7.3 OTHER COST CONSIDERATIONS

In addition to the proposed controls on air emissions, phosphate rock producers are presently incurring costs to control water-born effluents. Because these costs represent normal investment and operating costs, they are included as a part of the uncontrolled plant costs in the following section. These costs are incurred only by Eastern producers. Western producers can operate with no discharge and without incremental expenditures on control equipment because of the characteristics of the rock mined there, the process practices dictated by those characteristics, and a favorable balance between rainfall and evaporation.

The costs to Eastern producers are wholly incurred in treating and storing suspended solids. The EPA regulations require the effluent discharge to have a total suspended solids concentration not exceeding 30 mg/l for a 30 day average, or 60 mg/l maximum average for any one day. The investment and operating costs for a model plant with a capacity of 2.4 million metric tons is given in Table 7-21. Controls consist of pond treatment of the slimes and sand tailings. Costs were updated from their 1974 values to 1977 values using an inflator of 1.23.

Table 7-21. COST OF COMPLIANCE FOR MODEL EASTERN PHOSPHATE ROCK MINING AND BENEFICIATING FACILITY, 1977

Invested Capital Costs	
Total	$13,751,400
Annual Capital Recovery	1,731,000
Operating and Maintenance Costs	
Annual O & M	619,000
Annual Energy and Power	413,000
Total Annual Costs	2,763,000
Cost/Metric Ton of Product	$ 1.61
Raw Waste Load Parameters (mg/liter)	
Suspended Solids	3-560
Dissolved Fluoride	2*
Phosphorus (total)	4*

Sources: Development Document and Arthur D. Little, Inc. estimates.

Notes: The model plant has a capacity of 2.4 million metric tons per year, is 15 years old, and is located in the Eastern region (Florida, North Carolina, and Tennessee).

*Estimates average values.

7.4 ECONOMIC IMPACT ANALYSIS OF ALTERNATIVE EMISSION CONTROL SYSTEMS

7.4.1 Introduction

In this section, the potential economic impact on the phosphate rock industry of imposing various particulate emission control levels will be analyzed. In so doing, model plants representing typical new and modified plants in Florida and in the West will be developed and the investment and annual operating costs for each will be estimated. Based on the information presented in section 7.2, the costs of the alternative emission control systems will be estimated so that the control costs can be compared with the overall plant economics. Finally, the incremental costs of compliance under various new source performance standard (NSPS) levels will be compared to the control costs of the emissions reduction already required under the appropriate State Implementation Plans (SIP) in order to analyze the economic impact resulting from implementing those levels.

In the U.S. phosphate rock industry, every operation is different in some respect. In addition to differences in the sizes of the mines and processing plants, there are important and significant differences in overburden thickness, matrix thickness, and rock quality. Processing operations differ since plants dry, grind, and calcine different amounts of rock and use different types of equipment to perform these operations. Furthermore, some plants are associated with larger fertilizer complexes while other plants are not. As a result of these plant differences, it is difficult to construct a model plant for analytical purposes that takes into account all of these variations. However, reasonable assumptions have been made and the costs estimated for hypothetical new operations that are considered to be representative of the phosphate rock industry.

In considering the costs of the alternative emission control systems, three control options were devised which reflect the range of equipment combinations which can be employed to meet the NSPS and SIP levels. Control option A, which employs fabric filters to control emissions, and option B, which uses filters on grinding plants and Venturi scrubbers on all other facilities, have similar annual costs. Control option C, which utilizes electrostatic precipitators (ESP's) on all operations except grinders, is significantly more expensive than the other two technologies. Based on current industry practice, control option B represents the most typical control system. Other combinations of equipment could be used, but the control options developed in this chapter reflect the range of control costs and indicate the cost of the most typical systems.

7.4.2 Model Plant Analysis for the Florida Region

7.4.2.1 Investment and Operating Costs for a New Uncontrolled Florida Plant--

The model plant for the Florida region has a capacity of 2,381,400 metric tons of rock per year. It mines and processes 1,905,120 metric tons per year, a capacity utilization of 80 percent. Operations for this plant involve mining the phosphate matrix with a dragline (which also removes the overburden), slurrying the matrix in a sump, and pumping the slurry to a beneficiation plant. At the beneficiation plant, washing and sizing produce a coarse pebble product and remove the slimes; a double flotation process upgrades the rock to the finished product which is dried and ground. The rock is dried in two 145 metric tons per hour (tph) rotary dryers. Forty percent of the dried rock is ground in one 91 tph ball mill and two 14 tph roller mills. The remaining 60 percent of the dried rock is sold to other processors.

The costs of mining and beneficiating phosphate rock will increase dramatically for new operations, and not just because of increases in equipment costs. Nearly all of the high quality rock in Florida has already been mined or will be mined shortly, thus leaving only the lower quality rock. Producers are having to dig deeper in order to obtain the rock and also to mine a larger matrix to obtain a ton of marketable rock. This requires much larger mining equipment than was needed 5 to 10 years ago and also requires a larger beneficiation plant to prepare the product for drying and grinding. Finally, the cost of land is increasing because of competing uses for the land and because the supply of mineable land is steadily decreasing.

Whereas older plants and mines could be built and put into operation at an investment of about $10.00 per annual ton of capacity, costs have escalated to the point that the investment for a new mine and plant is at least double that and could grow to around $40-45 per annual ton of capacity.[31,32] Based on the best information available to EPA at the present time, it is estimated that an uncontrolled plant with a capacity of 2,381,400 metric tons of rock per year would require a capital outlay of over $85,932,000 or almost $36.08 per annual metric ton of capacity.[33] This investment includes nearly $34,500,000 for mining operations (see Table 7-22) and almost $51,500,000 for the processing plant, including the costs of water pollution control equipment (see Table 7-23).

The annual operating costs for mining and processing operations take into account charges for power, fuel, maintenance and repair, labor, local taxes, insurance, overhead, and other miscellaneous supplies and items. The annual operating cost for mining operations is estimated to be about $8,619,000 (see Table 7-24), while the costs for operating the processing plant are estimated

Table 7-22. ESTIMATED FLORIDA MINING INVESTMENT COST[33]

Operation	Thousands of dollars
Dragline	28,554
Hydraulic Water Pumps, Pipelines, etc.	1,259
Hydraulic Monitor Operation	155
Slurry Pumping	2,060
Drainage, Dams, Roads, Clearing Land, etc.	1,356
Prospecting	346
Miscellaneous Equipment	359
Mining Overhead (Mine Shops, Office, etc.)	375
	$34,464

Cost Per Annual Metric Ton (80% capacity utilization) = $18.09

Table 7-23. ESTIMATED INVESTMENT FOR UNCONTROLLED FLORIDA PROCESSING PLANT (Capacity: 2,381,400 metric tons)

Operation	Thousands of dollars
Washing, Screening, and Flotation	28,334
Dryers - 2 145 M.T./Hr Rotary	2,704
Grinders:	
1 Ball Mill - 91 M.T./Hr	244
2 Roller Mills - 14 M.T./Hr	749
Pneumatic Transfer Systems	206
Storage	2,325
Water Pollution Control	13,751
Miscellaneous Equipment	3,155
	$51,468

Cost Per Annual Metric Ton (80% capacity utilization) = $27.02

Table 7-24. ESTIMATED ANNUAL OPERATING COST FOR FLORIDA MINING OPERATIONS[33]
(Thousands of dollars)

Operation	Power kWh (10^6)	Power \$@ \$.03 per kWh	Maintenance and repair	Labor	Misc.	Taxes and insurance	Total
Dragline	33.1	993	1,134	230	-	563	2,920
Hydraulic Water	38.3	1,149	50	-	-	25	1,224
Hydraulic Monitor	-[a]	-	4	230	-	3	237
Slurry Pumping	40.8	1,224	120	78	479	41	1,942
Drainage, etc.	-	-	-	-	703	-	703
Prospecting	-	-	19	56	24	7	106
Misc. Equipment	-	-	-	-	29	7	36
Mining Overhead	-	-	-	167	19	8	194
Land Investment Royalty (@ \$.66 per M.T.)					1,257		1,257
	112.2	3,366	1,327	761	2,511	654	8,619

Dollars Per Metric Ton (80% capacity utilization) = \$4.52

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[a] Included in total above.

to be $14,829,000 per year (see Table 7-25). Thus, the total operating cost for mining and processing is about $12.30 per metric ton of product if the plant is utilized at 80 percent of capacity.

7.4.2.2 Summary of Control Costs for Florida Model Plant--

Table 7-26 summarizes the costs of alternative emission control systems for the new model plant. Included are the costs of controlling the drying plant, which contains two rotary dryers, and the grinding plant, which has one ball mill and two roller mills. Control option B (see Table 7-26) is considered to be the most typical control system for the entire model plant since scrubbers are the most common control technique used for dryers and fabric filters are the most common device used to control emissions from grinders. Control option A uses fabric filters on both dryers and grinders. Control option C employs electrostatic precipitators on the dryers and fabric filters on the grinders.

For each control option, three sets of costs are provided: (1) installed capital cost, (2) total annualized cost, and (3) annual total cost. The installed capital cost and the total annualized cost are taken from section 7.2. Total annualized costs include a capital recovery charge based on an interest rate of 10 percent and the lifetime of the capital equipment. The annual total cost is equal to total annualized cost minus the capital recovery charge; that is, the annual total cost is just the sum of the fixed and variable operating costs. This cost is used in the economic analysis, since the analytical technique (discounted cash flow rate of return) implicitly accounts for depreciation and recovery of the initial capital investment. The total annualized costs for each option are used to calculate the inflationary impacts of the NSPS in section 7.5.

Table 7-25. ESTIMATED OPERATING COSTS FOR UNCONTROLLED FLORIDA PROCESSING PLANT[33]

	Basis	Thousands of dollars
Power	41.7×10^6 kWh @ \$0.03/kWh	1,250
Fuel	9.4×10^6 gal. @ \$0.28/gal.	2,644
Reagents		4,369
Direct Operating Labor		1,871
Water Pollution Control		824
Maintenance Labor		784
Maintenance Supplies	2% of investment/yr.	1,029
Administration and Overhead	2% of investment/yr.	1,029
Taxes and Insurance	2% of investment/yr.	1,029
		14,829

Dollars Per Metric Ton (80% capacity utilization) = \$7.78

Table 7-26. FLORIDA MODEL PLANT CONTROL COSTS (10^3\$)
(Capacity = 2,381,400 metric tons per year)

			Option A[a]			Option B[b]			Option C[c]		
	Control level	Control efficiency (% controlled)	Installed capital cost	Total annualized cost	Annual total cost[d]	Installed capital cost	Total annualized cost	Annual total cost[d]	Installed capital cost	Total annualized cost	Annual total cost[d]
Drying plant[e]	NSPS 1	99.3	1,702	512	287	1,066	602	429	4,086	1,224	559
	NSPS 2	98.7[f]	1,702	512	287	1,066	534	360	2,958	972	491
	NSPS 3	97.9[f]	1,702	512	287	1,066	502	327	2,374	842	456
	SIP	95.5[f]	1,702	512	287	1,066	468	294	1,780	710	420
Grinding plant[g]	NSPS 1	99.6	320	79	37	320	79	37	320	79	37
	NSPS 2	99.6	320	79	37	320	79	37	320	79	37
	NSPS 3	99.6	320	79	37	320	79	37	320	79	37
	SIP	99.6	320	79	37	320	79	37	320	79	37
Total cost	NSPS 1	-	2,022	591	324	1,386	681	466	4,406	1,303	596
	NSPS 2	-	2,022	591	324	1,386	613	397	3,278	1,051	528
	NSPS 3	-	2,022	591	324	1,386	581	364	2,694	921	493
	SIP	-	2,022	591	324	1,386	547	331	2,100	789	457
Cost per metric ton	NSPS 1	-	1.06	0.31	0.17	0.73	0.36	0.25	2.31	.68	.31
	NSPS 2	-	1.06	0.31	0.17	0.73	0.32	0.21	1.72	.55	.28
	NSPS 3	-	1.06	0.31	0.17	0.73	0.30	0.19	1.41	.48	.26
	SIP	-	1.06	0.31	0.17	0.73	0.29	0.18	1.10	.41	.24

[a] Option A uses fabric filters as control devices.

[b] Option B uses wet scrubbers on the dryers and fabric filters on the grinding mills.

[c] Option C uses electrostatic precipitators on the dryers and fabric filters on the grinding mills.

[d] Annual total cost does not include the capital recovery charge. It is equal to total annualized cost minus the capital recovery charge.

[e] Drying plant contains two 145 tph rotary dryers, each ducted to separate control devices.

[f] Applies to options B and C. For option A, efficiency is 99.3 percent.

[g] Grinding plant contains one 91 tph ball mill and two 14 tph roller mills, each ducted to separate control devices.

As can be seen from Table 7-26, the total annualized cost of control option A is $0.31 per metric ton for all control levels. Option B ranges from $0.29 to $0.36 per metric ton, while option C ranges from $0.41 per ton for the SIP level to $0.68 per ton for the most stringent NSPS level. The capital requirements for the alternative control systems are approximately $1,386,000 for option B, $2,022,000 for option A, and from $2,100,000 to $4,406,000 for option C.

Table 7-27 gives the control costs for an existing plant whose capacity is expanded by 50 percent to 3,572,100 metric tons per year by adding one 145 tph rotary dryer and four 14 tph roller mills. These costs also reflect a capacity utilization of 80 percent. The dryers and grinders in the existing plant would be unaffected by the NSPS, but would have to meet the SIP standards. The new dryer and grinders, on the other hand, would have to meet the NSPS level, if it differed from the SIP standard. Thus, the control costs for the expansion are added to those required to meet the SIP level in the existing plant to calculate control costs for the entire facility.

The total annualized cost of controlling the emissions from the expansion would be $0.38 to $0.45 per metric ton for option B, the most typical control system (see Table 7-27). Meanwhile, option A would cost $0.41 per metric ton and option C would cost from $0.50 to $0.77 per metric ton. Adding these costs to the costs of controlling the emissions from the existing plant gives the control costs for the entire plant (also shown in Table 7-27). Depending on the control level, the annualized cost o[illegible]missions reduction would range from $0.32 to $0.34 per metric ton for option B, $0.34 per ton for option A, and $0.44 to $0.53 per ton for option C.

Table 7-27. FLORIDA MODIFIED PLANT CONTROL COSTS - 50% EXPANSION (10^3\$) (Capacity = 3,572,100 metric tons per year)

			Option A[a]					
			Expansion			Entire plant[d]		
	Control level	Control efficiency (% controlled)	Installed capital cost	Total annualized cost	Annual total cost[e]	Installed capital cost	Total annualized cost	Annual total cost[e]
Drying plant[f]	NSPS 1	99.3[g]	1,100	306	161	2,802	818	448
	NSPS 2	98.7[g]	1,100	306	161	2,802	818	448
	NSPS 3	97.9[g]	1,100	306	161	2,802	818	448
	SIP	95.5[g]	1,100	306	161	2,802	818	448
Grinding plant[h]	NSPS 1	99.6	302	80	41	622	159	78
	NSPS 2	99.6	302	80	41	622	159	78
	NSPS 3	99.6	302	80	41	622	159	78
	SIP	99.6	302	80	41	622	159	78
Total cost	NSPS 1	-	1,402	386	202	3,424	977	526
	NSPS 2	-	1,402	386	202	3,424	977	526
	NSPS 3	-	1,402	386	202	3,424	977	526
	SIP	-	1,402	386	202	3,424	977	526
Cost per metric ton	NSPS 1	-	1.47	0.41	0.21	1.20	0.34	0.18
	NSPS 2	-	1.47	0.41	0.21	1.20	0.34	0.18
	NSPS 3	-	1.47	0.41	0.21	1.20	0.34	0.18
	SIP	-	1.47	0.41	0.21	1.20	0.34	0.18

[a] Option A uses fabric filters as control devices.

[b] Option B uses a wet scrubber on the dryer and fabric filters on the grinding mills.

[c] Option C uses an electrostatic precipitator on the dryer and fabric filters on the grinding mills.

[d] Control costs for existing plant taken from Table 7-26, using the SIP control level.

[e] Does not include the capital recovery charge. Annual total cost is total annualized cost minus the capital recovery charge.

[f] Expanded portion of drying plant contains one 145 tph rotary dryer ducted to a control device.

[g] Applies only to the expansion for options B and C; for option A, the control efficiency of the expanded portion is 99.3 percent.

[h] Expanded portion of grinding plant contains four 14 tph roller mills, each ducted to a separate control device.

Table 7-27. FLORIDA MODIFIED PLANT CONTROL COSTS - 50% EXPANSION (10^3\$)
(Capacity = 3,572,100 metric tons per year)

			Option B[b]					
			Expansion			Entire plant[d]		
	Control level	Control efficiency (% controlled)	Installed capital cost	Total annualized cost	Annual total cost[e]	Installed capital cost	Total annualized cost	Annual total cost[e]
Drying plant[f]	NSPS 1	99.3[g]	762	353	229	1,828	821	523
	NSPS 2	98.7[g]	762	320	196	1,828	788	490
	NSPS 3	97.9[g]	762	303	179	1,828	771	473
	SIP	95.5[g]	762	286	162	1,828	754	456
Grinding plant[h]	NSPS 1	99.6	302	80	41	622	159	78
	NSPS 2	99.6	302	80	41	622	159	78
	NSPS 3	99.6	302	80	41	622	159	78
	SIP	99.6	302	80	41	622	159	78
Total cost	NSPS 1	-	1,064	433	270	2,450	980	601
	NSPS 2	-	1,064	400	237	2,450	947	568
	NSPS 3	-	1,064	383	220	2,450	930	551
	SIP	-	1,064	366	203	2,450	913	534
Cost per metric ton	NSPS 1	-	1.12	0.45	0.28	0.86	0.34	0.21
	NSPS 2	-	1.12	0.42	0.25	0.86	0.33	0.20
	NSPS 3	-	1.12	0.41	0.23	0.86	0.33	0.19
	SIP	-	1.12	0.38	0.21	0.86	0.32	0.19

[a] Option A uses fabric filters as control devices.

[b] Option B uses a wet scrubber on the dryer and fabric filters on the grinding mills.

[c] Option C uses an electrostatic precipitator on the dryer and fabric filters on the grinding mills.

[d] Control costs for existing plant taken from Table 7-26, using the SIP control level.

[e] Does not include the capital recovery charge. Annual total cost is total annualized cost minus the capital recovery charge.

[f] Expanded portion of drying plant contains one 145 tph rotary dryer ducted to a control device.

[g] Applies only to the expansion for options B and C; for option A, the control efficiency of the expanded portion is 99.3 percent.

[h] Expanded portion of grinding plant contains four 14 tph roller mills, each ducted to a separate control device.

Table 7-27. FLORIDA MODIFIED PLANT CONTROL COSTS - 50% EXPANSION (10^3\$)
(Capacity = 3,572,100 metric tons per year)

			Option C[c]					
			Expansion			Entire plant[d]		
	Control level	Control efficiency (% controlled)	Installed capital cost	Total annualized cost	Annual total cost[e]	Installed capital cost	Total annualized cost	Annual total cost[e]
Drying plant[f]	NSPS 1	99.3[g]	2,215	650	290	3,995	1,360	710
	NSPS 2	98.7[g]	1,651	525	256	3,431	1,235	676
	NSPS 3	97.9[g]	1,350	460	238	3,130	1,170	658
	SIP	95.5[g]	1,063	394	221	2,843	1,104	641
Grinding plant[h]	NSPS 1	99.6	302	80	41	622	159	78
	NSPS 2	99.6	302	80	41	622	159	78
	NSPS 3	99.6	302	80	41	622	159	78
	SIP	99.6	302	80	41	622	159	78
Total cost	NSPS 1	-	2,517	730	331	4,617	1,519	788
	NSPS 2	-	1,953	605	297	4,053	1,394	754
	NSPS 3	-	1,652	540	279	3,752	1,329	736
	SIP	-	1,365	474	262	3,465	1,263	719
Cost per metric ton	NSPS 1	-	2.64	0.77	0.35	1.62	0.53	0.28
	NSPS 2	-	2.05	0.64	0.31	1.42	0.49	0.26
	NSPS 3	-	1.73	0.57	0.29	1.31	0.47	0.26
	SIP	-	1.43	0.50	0.28	1.21	0.44	0.25

[a] Option A uses fabric filters as control devices.

[b] Option B uses a wet scrubber on the dryer and fabric filters on the grinding mills.

[c] Option C uses an electrostatic precipitator on the dryer and fabric filters on the grinding mills.

[d] Control costs for existing plant taken from Table 7-26, using the SIP control level.

[e] Does not include the capital recovery charge. Annual total cost is total annualized cost minus the capital recovery charge.

[f] Expanded portion of drying plant contains one 145 tph rotary dryer ducted to a control device.

[g] Applies only to the expansion for options B and C; for option A, the control efficiency of the expanded portion is 99.3 percent.

[h] Expanded portion of grinding plant contains four 14 tph roller mills, each ducted to a separate control device.

For the entire plant, the capital requirements for the alternative control systems would be $2,450,000 for option B, $3,424,000 for option A, and from $3,465,000 to $4,615,000 for option C.

7.4.2.3 Economic Impact on New Model Plant--

A discounted cash flow rate of return (DCFRR) technique is used to calculate the economic impacts of imposing different NSPS control levels on the model plants. This involves calculating the net annual after-tax cash flow generated by the investment in the new or modified plant and discounting this cash flow over the life of the project. (The lifetime of the plants was assumed to be 20 years). The interest rate which results in a stream of discounted cash flows whose sum is zero is called the internal rate of return (IRR).

An IRR is calculated for a plant utilizing each of the control options under each of the NSPS control levels. These IRR's are then compared to a baseline IRR, which was calculated from a plant meeting the SIP level of control by Option B (scrubbers on the dryers and fabric filters on the grinders), since this is the most economical method for plants to conform to proposed state regulations.

The method and assumptions used to calculate the IRR's are described below. The selling price of phosphate rock from a typical Florida plant was assumed to be $19.80 per metric ton and was assumed to remain constant over the life of the plant. The baseline cost of production for an uncontrolled plant was $12.30 per metric ton; this was derived in section 7.4.2.1. The unit control costs were taken from Table 7-26. The production and control costs are annual total costs, that is, they do not include a capital recovery charge. The sum of the unit baseline production and the unit control costs were subtracted from the selling price to get profits before tax. This figure was multiplied by .52 to determine after-tax profits per ton of phosphate rock produced. (The corporate tax rate was assumed to be 48 percent.) Total plant capital, including the cost of controls, per ton of rock produced was calculated from the mining and processing investment costs in Tables 7-22 and 7-23; investment in the control equipment was taken from Table 7-26. It was assumed that all of this investment was made prior to startup of the plant. Using an iterative procedure, various interest rates were used to discount the stream of after-tax profits over 20 years; the interest rate that equated the sum of these discounted cash flows with the investment per ton of product represented the internal rate of return for that investment.

The baseline return on investment for a new Florida plant was estimated to be 5.4 percent (see Table 7-28). This is a low rate of return, which might seem to contradict the industry's plans for expansion in this region. However, several points not explicitly incorporated in the analysis might help resolve this discrepancy. First, the analysis assumes a constant selling price for phosphate rock. In actuality, producers planning to enter the industry or to expand existing capacity may anticipate higher (and more stable) prices in the future that would increase the rate of return. Second, a higher rate of capacity utilization would lower unit production costs, raise profits, and increase return on investment. Third, the analysis does not allow for an investment tax credit, which would also increase the IRR. Fourth, it was assumed that none of the investment was financed through borrowing. Borrowing a portion of the required capital would also increase the IRR, because only the amount of the investment financed out of equity or retained earnings enters into the internal rate of return calculations as total plant capital.

Table 7-28. PROFITABILITY IMPACT ANALYSIS OF CONTROL OPTIONS ON NEW FLORIDA PLANT (Dollars per metric ton)

Control level:	SIP	NSPS 1			NSPS 2			NSPS 3		
Control option:	B	A	B	C	A	B	C	A	B	C
Sales	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Base line production costs (80% utilization)	12.30	12.30	12.30	12.30	12.30	12.30	12.30	12.30	12.30	12.30
Control costs	0.18	0.17	0.25	0.31	0.17	0.21	0.28	0.17	0.19	0.26
Profit before tax	7.32	7.33	7.25	7.19	7.33	7.29	7.22	7.33	7.31	7.24
Profit after tax (48% tax rate)	3.81	3.81	3.77	3.74	3.81	3.79	3.75	3.81	3.80	3.76
Total plant capital (incl. controls)	45.83	46.17	45.84	47.42	46.17	45.84	46.83	46.17	45.84	46.52
Internal rate of return (%)	5.40	5.33	5.30	4.80	5.33	5.35	5.00	5.33	5.38	5.10
Decline in IRR from SIP, Option B (%)	-	1.30	1.85	11.11	1.30	0.93	7.41	1.30	0.37	5.56
Price needed to maintain IRR	-	19.84	19.87	20.18	19.84	19.82	20.05	19.84	19.81	19.98
Price increase to maintain IRR (%)	-	0.19	0.33	1.91	0.19	0.13	1.28	0.19	0.03	0.93

In the analysis that follows, two types of impacts will be considered. First, it is assumed that the producer absorbs the incremental cost of complying with each NSPS control level. The impact of this full cost absorption is measured by the decline in return on investment from the baseline IRR. Second, it is assumed that the producer raises the selling price enough to maintain the IRR investment at its baseline level. This is a case of full cost pass-through.

Option A

Table 7-28 shows that the impacts of the proposed standard are the same at all levels if fabric filters are used to control emissions from the dryers and grinders. Under full cost absorption, the return to capital declines by 1.3 percent from the baseline level. Under full cost pass-through, the price would need to rise from $19.80 per metric ton to $19.84, an increase of 0.19 percent, to maintain return on investment at its baseline level.

Option B

Under full cost absorption, the return to capital would decline by 1.9 percent if the stringent level of control (NSPS 1) were imposed. If more moderate levels of control were implemented (NSPS 2 and NSPS 3), the decline would be 0.9 and 0.4 percent, respectively. Under full cost pass-through, producers would need to raise the price by 0.3 percent (from $19.80 to $19.87) to maintain return on investment if the stringent control level were implemented. At the NSPS 2 and NSPS 3 control levels, price increases of 0.13 and 0.3 percent, respectively, would be needed.

Option C

As Table 7-28 shows, the most severe impacts would occur if electrostatic precipitators were used on the dryers and fabric filters were used to control emissions from the grinders. Under full cost absorption, the decline in return on investment would range from 11 percent at NSPS 1 to 5.6 percent at NSPS 3. Under full cost pass-through, the price increase necessary to maintain return on investment at its baseline level would range from 1.9 percent at the stringent control level to 0.9 percent at the moderate level of control.

Summary

From the discussion in this section, producers would use fabric filters on the dryers and grinders (option A) if the stringent level of control (NSPS 1) were imposed. Employing this option to meet the standard minimizes the impacts on return on investment (full cost absorption) and on price (full cost pass-through). If either the NSPS 2 or NSPS 3 level of control were imposed, the producer would choose option B, which consists of wet scrubbers on the dryers and fabric filters on the grinders. Option C would never be selected, since the cost of this option is significantly higher than that incurred by using options A or B at each control level. Thus, the impacts of complying with any of the proposed NSPS levels are insignificant.

7.4.2.4 Economic Impact on Modified Model Plant--

For the modified model plant, it is assumed that a 2,381,400 metric ton per year existing plant expands capacity by 50 percent. The control costs for this modified plant were presented in section 7.4.2.2. It is assumed that the modified plant utilizes 80 percent of its capacity. In order to conduct the impact analysis, the following assumptions were made: the rock sells for an average price of $19.80 per metric ton; the existing plant operates at a cost of $8.78 per metric ton and was built with a capital investment of $13.09 per metric ton; the new facilities of the expanded plant operate at a cost of $17.26 per metric ton and could be built with a capital investment of $50.61 per metric ton; and the entire expanded plant operates at a cost of $11.61 per metric ton and could be built with a capital investment of $25.60 per metric ton, not including the cost of emissions control.

The impacts on the modified plant were calculated using the same approach as was used for the new Florida plant. The baseline internal rate of return was estimated at 14.7 percent and was based on the costs of a modified plant that meets the SIP requirements by Option B. The economics of the expanded plant are more favorable than those of the new plant, because the investment and operating costs of the existing plant are much lower. The results of the analysis are given in Table 7-29.

Option A

As Table 7-29 shows, the impacts of the proposed standard are the same at all levels of control. Under full cost absorption, the decline in return on investment from its baseline level is 1.5 percent. Under full cost pass-through, the price would need to rise from $19.80 to $19.90, an increase of 0.5 percent, to maintain the rate of return at its baseline level.

Option B

Under full cost absorption, imposition of the stringent control level (NSPS 1) would cause return on investment to decline by 0.3 percent. Under the NSPS 2 and NSPS 3 control levels, the IRR would decline by 0.14 and

Table 7-29. PROFITABILITY IMPACT ANALYSIS OF CONTROL OPTIONS ON MODIFIED FLORIDA PLANT

(Dollars per metric ton)

Control level: Control option:	SIP B	NSPS 1 A	 B	 C	NSPS 2 A	 B	 C	NSPS 3 A	 B	 C
Sales	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Base line production costs (80% utilization)	11.61	11.61	11.61	11.61	11.61	11.61	11.61	11.61	11.61	11.61
Control costs	0.19	0.18	0.21	0.28	0.18	0.20	0.26	0.18	0.19	0.26
Profit before tax	8.00	8.01	7.98	7.91	8.01	7.99	7.93	8.01	8.00	7.93
Profit after tax (48% tax rate)	4.16	4.17	4.15	4.11	4.17	4.15	4.12	4.17	4.16	4.12
Total plant capital (incl. controls)	26.64	26.80	26.46	27.22	26.80	26.46	26.99	26.80	26.46	26.91
Internal rate of return (%)	14.72	14.50	14.67	14.03	14.50	14.70	14.18	14.50	14.71	14.26
Decline in IRR from SIP, Option B (%)	-	1.49	0.34	4.68	1.49	0.14	3.67	1.49	0.07	3.13
Price needed to maintain IRR	-	19.90	19.82	20.12	19.90	19.81	20.03	19.90	19.80	20.01
Price increase to maintain IRR (%)	-	0.51	0.10	1.62	0.51	0.05	1.16	0.51	0.00	1.06

0.07 percent, respectively. Under full cost pass-through, a price increase of 0.1 percent would be required to maintain the return on investment if the stringent level of control were imposed. The price increases under the more moderate control levels are essentially zero. Furthermore, the capital requirements of the plant under any of the NSPS levels would be unchanged from those required under the SIP level.

Option C

Employing electrostatic precipitators on the dryers and fabric filters on the grinders would cause severe impacts at all control levels. Under full cost absorption, the decline in return on investment would range from 4.7 percent (NSPS 1) to 3.1 percent (NSPS 3). Under full cost pass-through, the price increases needed to maintain return on investment at its baseline level would range from 1.6 percent (NSPS 1) to 1.1 percent (NSPS 3).

Summary

If modifications to an existing plant were undertaken, producers would choose option B (wet scrubbers on the dryers and fabric filters on the grinders) regardless of the level of control. Even at the stringent control level, the impacts are very small. Again, option C would never be selected as the control level, because of the significantly higher capital and annual costs associated with this option.

7.4.3 Model Plant Analysis for the Western Region

7.4.3.1 Investment and Operating Costs for a New Uncontrolled Western Plant--

For the Western phosphate region, the model plant has a capacity of 1,270,000 metric tons, and produces 1,016,000 metric tons of marketable rock per year (a capacity utilization of 80 percent). This scheme assumes an open pit mine in the mountains where the ore is mined, segregated and stockpiled. There is a 25 mile contracted truck haul to the milling site, where the rock undergoes crushing, sizing, desliming, and filtration. The calcining plant, the next step in the process, includes three 54 tph fluid bed calciners, while the grinding plant contains one 91 tph ball mill and two 14 tph roller mills. Not all of the calcined rock is ground--25 percent is sold to other processors.

The investment and operating costs of a Western mine and uncontrolled processing plant are detailed in Tables 7-30, 7-31, and 7-32[34]. Mining equipment and maintenance facilities would require an estimated capital investment of over $10,000,000, or about $8.15 per metric ton of capacity. Meanwhile, the investment for the uncontrolled processing plant would amount to an estimated $23,562,000 or $18.55 per metric ton of capacity (see Table 7-31). Thus, the total capital needed to construct a new mine and plant would be $34,094,000 or about $26.70 per metric ton of capacity.

The annual operating costs for the mining and processing operations were estimated in a manner similar to that used for the Florida plant, assuming a capacity utilization of 80 percent. For the mining operations, the annual costs would be about $7,564,000 (see Table 7-30), while the costs for operating the processing plant are estimated to be $6,557,000 (see Table 7-32). The total operating costs for mining and processing amount to about $13.89 per metric ton of product per year.

7.4.3.2 Summary of Control Costs for Western Model Plant--

Table 7-33 presents a summary of the costs of alternative emission control systems for the new model plant. As was the case for the Florida plant, three types of costs are provided for each control system: (1) installed

Table 7-30. ESTIMATED WESTERN MINING INVESTMENT AND OPERATING COSTS[34]
(Capacity: 1,270,000 metric tons per year)

Investment for Mining Equipment and Maintenance Facilities:	$10,352,000
Investment per Ton of Product (80% capacity utilization) = $10.19	

Operating costs (80% capacity utilization)	Thousands of dollars
Supplies:	
Diesel Fuel	709
Oil, Gasoline, Grease, Etc.	143
Tires	201
Blasting Supplies	262
Total	1,315
Direct Operating Labor	1,252
Maintenance Labor	442
Maintenance Supplies	696
Administrative Overhead	208
Truck Haulage to Processing Site	3,005
Local Taxes and Insurance	207
Land Investment Royalty ($0.28 per metric ton)	439
Total Operating Costs	7,564
Cost Per Metric Ton (80% capacity utilization) = $7.44	

Table 7-31. ESTIMATED INVESTMENT FOR UNCONTROLLED WESTERN PROCESSING PLANT[34]
(Capacity: 1,270,000 metric tons per year)

	Thousands of dollars
Beneficiation	4,012
Calciners - 3 54 tph Fluid Bed	14,347
Grinders:	
1 91 tph Ball Mill	255
2 14 tph Roller Mills	766
Pneumatic Transfer Systems	200
Storage Facilities	2,844
Miscellaneous Equipment	1,138
Total Investment	23,562
Cost Per Metric Ton (80% capacity utilization) = $23.19	

Table 7-32. ESTIMATED OPERATING COSTS FOR UNCONTROLLED WESTERN PROCESSING PLANT[34]

(Capacity: 1,270,000 metric tons per year)

	Basis	Thousands of dollars
Supplies:		
Power	42.6×10^6 kWh @ \$0.03/kWh	1,278
Fuel-Bunker C	12.2×10^6 gal @ \$0.28/gal	3,416
Water	800×10^6 gal @ \$0.03/1,000 gal	24
Direct Operating Labor		451
Maintenance Labor		261
Administrative Overhead		185
Maintenance Supplies	2% of Investment Per Year	471
Local Taxes and Insurance	2% of Investment Per Year	471
Total Annual Operating Cost		6,557
Cost Per Metric Ton (80% capacity utilization) = \$6.45		

capital cost, (2) total annualized cost, and (3) annual total cost. The annual total costs are used in the economic impact analysis, while the annualized costs are used to estimate inflationary impacts in section 7.5. Control option B is considered to be the most typical control system for the entire model plant, since it includes wet scrubbers on the calciners and fabric filters on the grinders. Control option A, using fabric filters on both calciners and grinders, is comparable in cost to option B, while control option C, requiring electrostatic precipitators, has the highest capital and operating costs of the three options.

Control option A, according to Table 7-33, would require a capital investment of $3,114,000 and an annualized cost of $0.90 per ton, regardless of the control level. At all control levels, option B would require a capital investment of around $2,125,000. The annualized cost would range from $0.85 per ton at the SIP level to $1.06 per ton at the most stringent NSPS level. Finally, the costs of control option C range from $3,056,000 for capital equipment and an annualized cost of $1.17 per ton at the SIP level to $5,891,000 for capital and $1.80 per ton in annualized costs at the most stringent NSPS level.

The control costs for a modified plant are summarized in Table 7-34. For the purposes of this analysis, it is assumed that the calcining capacity of an existing plant is increased by 33 percent by adding one 54 tph calciner; grinding capacity is increased by 50 percent by adding four 14 tph roller mills. Again, the calciners and grinders of the existing plant would not be affected by the NSPS, but would have to meet the current SIP standard. The new calciner and grinders, however, would have to meet the appropriate NSPS level. Once again, the control costs for the expanded portion of the plant are added to those required to meet the SIP level in the existing plant to calculate control costs for the entire facility.

Table 7-33. WESTERN MODEL PLANT CONTROL COSTS (Thousands of dollars)
(Capacity = 1,270,000 metric tons per year)

			Option A[a]			Option B[b]			Option C[c]		
	Control level	Control efficiency (% controlled)	Installed capital cost	Total annualized cost	Annual total cost[d]	Installed capital cost	Total annualized cost	Annual total cost[d]	Installed capital cost	Total annualized cost	Annual total cost[d]
Calcining plant[e]	NSPS 1	99.0	2,794	837	470	1,805	996	702	5,571	1,746	839
	NSPS 2	97.4[f]	2,794	837	470	1,805	861	569	3,573	1,299	719
	NSPS 3	95.5[f]	2,794	837	470	1,805	807	513	2,916	1,155	679
	SIP	94.5[f]	2,794	837	470	1,805	783	490	2,736	1,113	669
Grinding plant[g]	NSPS 1	99.6	320	79	37	320	79	37	320	79	37
	NSPS 2	99.6	320	79	37	320	79	37	320	79	37
	NSPS 3	99.6	320	79	37	320	79	37	320	79	37
	SIP	99.6	320	79	37	320	79	37	320	79	37
Total cost	NSPS 1	-	3,114	916	507	2,125	1,075	739	5,891	1,825	876
	NSPS 2	-	3,114	916	507	2,125	940	606	3,893	1,378	756
	NSPS 3	-	3,114	916	507	2,125	886	550	3,236	1,234	716
	SIP	-	3,114	916	507	2,125	862	527	3,056	1,192	706
Cost per metric ton	NSPS 1	-	3.06	0.90	0.50	2.09	1.06	0.73	5.80	1.80	0.86
	NSPS 2	-	3.06	0.90	0.50	2.09	0.93	0.60	3.83	1.36	0.74
	NSPS 3	-	3.06	0.90	0.50	2.09	0.87	0.54	3.19	1.21	0.70
	SIP	-	3.06	0.90	0.50	2.09	0.85	0.52	3.01	1.17	0.69

[a] Option A uses fabric filters as control devices.

[b] Option B uses wet scrubbers on the calciners and fabric filters on the grinding mills.

[c] Option C uses electrostatic precipitators on the calciners and fabric filters on the grinding mills.

[d] Does not include the capital recovery charge. Annual total cost is equal to total annualized cost minus the capital recovery charge.

[e] Calcining plant contains three 54 mg/hr fluid bed calciners, each ducted to a separate control device.

[f] Applies to options B and C; under option A, control efficiency is 99.0 percent at all levels.

[g] Grinding plant contains one 91 mg/hr ball mill ducted to a control device and two 14 mg/hr roller mills, each ducted to a control device.

Table 7-34. MODIFIED WESTERN PLANT CONTROL COSTS--33 PERCENT EXPANSION (Thousands of dollars) (Capacity = 1,693,000 metric tons per year)

			Option A[a]					
			Expansion			Entire plant[d]		
	Control level	Control efficiency (% controlled)[e]	Installed capital cost	Total annualized cost	Annual total cost[f]	Installed capital cost	Total annualized cost	Annual total cost[f]
Calcining plant[g]	NSPS 1	99.0	1,206	312	153	4,000	1,149	623
	NSPS 2	97.4[h]	1,206	312	153	4,000	1,149	623
	NSPS 3	95.5[h]	1,206	312	153	4,000	1,149	623
	SIP	94.5[h]	1,206	312	153	4,000	1,149	623
Grinding plant[i]	NSPS 1	99.6	302	80	41	622	159	78
	NSPS 2	99.6	302	80	41	622	159	78
	NSPS 3	99.6	302	80	41	622	159	78
	SIP	99.6	302	80	41	622	159	78
Total cost	NSPS 1	-	1,508	392	194	4,622	1,308	701
	NSPS 2	-	1,508	392	194	4,622	1,308	701
	NSPS 3	-	1,508	392	194	4,622	1,308	701
	SIP	-	1,508	392	194	4,622	1,308	701
Cost per metric ton	NSPS 1	-	4.45	1.16	0.57	3.41	0.97	0.52
	NSPS 2	-	4.45	1.16	0.57	3.41	0.97	0.52
	NSPS 3	-	4.45	1.16	0.57	3.41	0.97	0.52
	SIP	-	4.45	1.16	0.57	3.41	0.97	0.52

[a] Option A uses fabric filters as control devices.

[b] Option B uses a wet scrubber on the calciner and fabric filters on the grinding mills.

[c] Option C uses an electrostatic precipitator on the calciner and fabric filters on the grinding mills.

[d] Control costs for existing plant taken from Table 7-33, using the SIP control level.

[e] Control efficiencies apply only to the expanded portion of the plant.

[f] Does not include the capital recovery charge. Annual total cost is equal to total annualized cost minus the capital recovery charge.

[g] Expanded portion of calcining plant contains one 54 mg/hr calciner ducted to a control device.

[h] Applies to options B and C; for option A, control efficiency is 99.0 percent at all levels.

[i] Expanded portion of grinding plant contains four 14 mg/hr roller mills, each ducted to a control device.

Table 7-34. MODIFIED WESTERN PLANT CONTROL COSTS--33 PERCENT EXPANSION (Thousands of dollars) (Capacity = 1,693,000 metric tons per year)

			Option B[b]					
			Expansion			Entire plant[d]		
	Control level	Control efficiency (% controlled)[e]	Installed capital cost	Total annualized cost	Annual total cost[f]	Installed capital cost	Total annualized cost	Annual total cost[f]
Calcining plant[g]	NSPS 1	99.0	861	342	202	2,666	1,125	692
	NSPS 2	97.4[h]	861	309	169	2,666	1,092	659
	NSPS 3	95.5[h]	861	295	155	2,666	1,078	645
	SIP	94.5[h]	861	289	149	2,666	1,072	639
Grinding plant[i]	NSPS 1	99.6	302	80	41	622	159	78
	NSPS 2	99.6	302	80	41	622	159	78
	NSPS 3	99.6	302	80	41	622	159	78
	SIP	99.6	302	80	41	622	159	78
Total cost	NSPS 1	-	1,163	422	243	3,288	1,284	770
	NSPS 2	-	1,163	389	210	3,288	1,251	737
	NSPS 3	-	1,163	375	196	3,288	1,239	723
	SIP	-	1,163	369	190	3,288	1,231	717
Cost per metric ton	NSPS 1	-	3.43	1.25	0.72	2.43	0.95	0.57
	NSPS 2	-	3.43	1.15	0.62	2.43	0.92	0.54
	NSPS 3	-	3.43	1.11	0.58	2.43	0.91	0.53
	SIP	-	3.43	1.09	0.56	2.43	0.91	0.53

[a] Option A uses fabric filters as control devices.

[b] Option B uses a wet scrubber on the calciner and fabric filters on the grinding mills.

[c] Option C uses an electrostatic precipitator on the calciner and fabric filters on the grinding mills.

[d] Control costs for existing plant taken from Table 7-33, using the SIP control level.

[e] Control efficiencies apply only to the expanded portion of the plant.

[f] Does not include the capital recovery charge. Annual total cost is equal to total annualized cost minus the capital recovery charge.

[g] Expanded portion of calcining plant contains one 54 mg/hr calciner ducted to a control device.

[h] Applies to options B and C; for option A, control efficiency is 99.0 percent at all levels.

[i] Expanded portion of grinding plant contains four 14 mg/hr roller mills, each ducted to a control device.

Table 7-34. MODIFIED WESTERN PLANT CONTROL COSTS--33 PERCENT EXPANSION (Thousands of dollars) (Capacity = 1,693,000 metric tons per year)

			Option C[c]					
			Expansion			Entire plant[d]		
	Control level	Control efficiency (% controlled)[e]	Installed capital cost	Total annualized cost	Annual total cost[f]	Installed capital cost	Total annualized cost	Annual total cost[f]
Calcining plant[g]	NSPS 1	99.0	2,043	581	249	4,779	1,694	918
	NSPS 2	97.4[h]	1,377	433	209	4,113	1,546	878
	NSPS 3	95.5[h]	1,158	384	195	3,894	1,497	864
	SIP	94.5[h]	1,098	371	192	3,834	1,484	861
Grinding plant[i]	NSPS 1	99.6	302	80	41	622	159	78
	NSPS 2	99.6	302	80	41	622	159	78
	NSPS 3	99.6	302	80	41	622	159	78
	SIP	99.6	302	80	41	622	159	78
Total cost	NSPS 1	-	2,345	661	290	5,401	1,853	996
	NSPS 2	-	1,679	513	250	4,735	1,705	956
	NSPS 3	-	1,460	464	236	4,516	1,656	942
	SIP	-	1,400	451	233	4,456	1,643	939
Cost per metric ton	NSPS 1	-	6.93	1.95	0.86	3.99	1.37	0.74
	NSPS 2	-	4.96	1.52	0.74	3.50	1.26	0.71
	NSPS 3	-	4.31	1.37	0.70	3.33	1.22	0.70
	SIP	-	4.13	1.33	0.69	3.29	1.21	0.69

[a] Option A uses fabric filters as control devices.

[b] Option B uses a wet scrubber on the calciner and fabric filters on the grinding mills.

[c] Option C uses an electrostatic precipitator on the calciner and fabric filters on the grinding mills.

[d] Control costs for existing plant taken from Table 7-33, using the SIP control level.

[e] Control efficiencies apply only to the expanded portion of the plant.

[f] Does not include the capital recovery charge. Annual total cost is equal to total annualized cost minus the capital recovery charge.

[g] Expanded portion of calcining plant contains one 54 mg/hr calciner ducted to a control device.

[h] Applies to options B and C; for option A, control efficiency is 99.0 percent at all levels.

[i] Expanded portion of grinding plant contains four 14 mg/hr roller mills, each ducted to a control device.

Under control option A, the annualized cost of controlling emissions from the new facilities would be $1.16 per metric ton for all control levels (see Table 7-34). Meanwhile, the annualized cost range for option B would be $1.09 to $1.25 per metric ton, while option C would range from $1.33 to $1.95 per metric ton. Incorporating these costs with the control costs for the existing plant, the annualized costs of reducing emissions from the entire plant would be $0.97 per metric ton for option A, $0.91 to $0.95 per ton for option B, and $1.21 to $1.37 per ton for option C. For the entire plant, the capital requirements for the alternative control systems would be $4,622,000 for option A, $3,288,000 for option B, and from $4,456,000 to $5,401,000 for option C.

7.4.3.3 Economic Impact on New Model Plant--

To determine the economic impact of imposing the different NSPS control levels on the new Western model plant, the same analytical approach used for the new and modified Florida plants was employed. This analysis assumed an average selling price of $22.04 per metric ton and an uncontrolled unit production cost of $13.89, which was derived in section 7.4.3.1. The control costs were reported in section 7.4.3.2.

The baseline IRR used in this analysis was calculated for a plant that met the SIP level of control by employing option B (scrubbers on the calciners and fabric filters on the grinders). As Table 7-35 shows, the rate of return is 9.3 percent.

Option A

Table 7-35 shows that the impacts on new plant economics are the same at all control levels. Under full cost absorption, the return on investment would decline by 3.9 percent from the baseline rate of return. Under

Table 7-35. PROFITABILITY IMPACT ANALYSIS OF CONTROL OPTIONS ON NEW WESTERN PLANT (Dollars per metric ton)

Control level:	SIP	NSPS 1			NSPS 2			NSPS 3		
Control option:	B	A	B	C	A	B	C	A	B	C
Sales	22.04	22.04	22.04	22.04	22.04	22.04	22.04	22.04	22.04	22.04
Base line production costs (80% utilization)	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89	13.89
Control costs	0.52	0.50	0.73	0.86	0.50	0.60	0.74	0.50	0.54	0.70
Profit before tax	7.63	7.65	7.42	7.29	7.65	7.55	7.41	7.65	7.61	7.45
Profit after tax (48% tax rate)	3.97	3.98	3.86	3.79	3.98	3.93	3.85	3.98	3.96	3.87
Total plant capital (incl. controls)	35.49	36.44	35.47	39.18	36.44	35.47	37.21	36.44	35.47	36.56
Internal rate of return (%)	9.30	8.94	8.90	7.30	8.94	9.13	8.24	8.94	9.23	8.50
Decline in IRR from SIP, Option B (%)	-	3.87	4.30	21.51	3.87	1.83	11.40	3.87	0.75	8.60
Price needed to maintain IRR	-	22.23	22.25	23.18	22.23	22.12	22.64	22.23	22.06	22.46
Price increase to maintain IRR (%)	-	0.87	0.97	5.18	0.87	0.38	2.71	0.87	0.10	1.89

full cost pass-through, producers would have to increase the price from $22.04 to $22.23 per metric ton, an increase of 0.9 percent, to maintain the return on investment at its baseline level.

Option B

Under full cost absorption, the rate of return would decline by 4.3 percent at the stringent level of control, by 1.8 percent at the NSPS 2 level, and by 0.8 percent at the NSPS 3 level. Under full cost pass-through, the price would need to rise by 1.0 percent at the NSPS 1 level, by 0.4 percent at the NSPS 2 level, and by 0.1 percent at the NSPS 3 level in order to maintain the return to capital at its baseline level. Furthermore, employing option B to meet the NSPS level of control would have no effect on total plant capital per ton of product, since this option would be used to meet the SIP level of control.

Option C

Selection of this option to meet the NSPS control levels would result in the most severe impacts on the plant economics. Under full cost absorption, the decline in return on investment would range from 22 percent (NSPS 1) to 9 percent (NSPS 3). Under full cost pass-through, the price increase needed to maintain the IRR would range from 5.2 percent (NSPS 1) to 1.9 percent (NSPS 3).

Summary

From the preceding discussion, it is concluded that option A (fabric filters on calciners and grinders) would be selected if the stringent level of control (NSPS 1) were the standard. Under the moderate levels of control (NSPS 2 and NSPS 3), option B (wet scrubbers on the calciners and fabric filters on the grinders) would be chosen. Under no circumstances would option C be chosen to comply with any of the control levels, because of the significantly higher capital and annual costs associated with this option.

7.4.3.4 Economic Impact on Modified Model Plant--

For the modified plant, it is assumed that the existing plant undergoes expansion of its calcining capacity by 33 percent and its grinding capacity by 50 percent. The control costs for this modified plant were presented in section 7.4.3.2. In order to conduct the impact analysis, the following assumptions were made: the rock sells for an average price of $22.04 per metric ton; the existing plant operates at a cost of $15.28 per ton and was built with a capital investment of $19.64 per ton; the new facilities of the expanded plant operate at a cost of $18.51 per ton and could be built with a capital investment of $43.65 per annual ton; and the entire expanded plant operates at a cost of $16.09 per ton and could be constructed with a capital outlay of $25.64 per annual ton, not including the cost of emission control. The results of the analysis are presented in Table 7-36. The baseline return on investment of 7.8 percent was calculated for a plant that met the SIP level of control using option B.

Option A

As Table 7-36 shows, the impacts on the rate of return and on price are the same at all of the NSPS control levels. Under full cost absorption, the decline in the return on investment is 5.3 percent. Under full cost pass-through, Western producers would have to raise the price from $22.04 to $22.22, an increase of 0.8 percent, to maintain the return to capital at its baseline level.

Table 7-36. PROFITABILITY IMPACT ANALYSIS OF CONTROL OPTIONS ON MODIFIED WESTERN PLANT (Dollars per metric ton)

Control level:	SIP	NSPS 1			NSPS 2			NSPS 3		
Control option:	B	A	B	C	A	B	C	A	B	C
Sales	22.04	22.04	22.04	22.04	22.04	22.04	22.04	22.04	22.04	22.04
Base line production costs (80% utilization)	16.09	16.09	16.09	16.09	16.09	16.09	16.09	16.09	16.09	16.09
Control costs	0.56	0.52	0.72	0.74	0.52	0.62	0.71	0.52	0.58	0.70
Profit before tax	5.39	5.43	5.23	5.21	5.43	5.33	5.24	5.43	5.37	5.25
Profit after tax (48% tax rate)	2.80	2.82	2.72	2.71	2.82	2.77	2.72	2.82	2.79	2.73
Total plant capital (incl. controls)	28.07	29.05	28.07	29.63	29.05	28.07	29.14	29.05	28.07	28.97
Internal rate of return (%)	7.80	7.39	7.68	6.61	7.39	7.76	6.89	7.39	7.78	6.99
Decline in IRR from SIP, Option B (%)	-	5.26	1.54	15.26	5.26	0.51	11.67	5.26	0.26	10.38
Price needed to maintain IRR	-	22.22	22.23	22.55	22.22	22.13	22.42	22.22	22.09	22.38
Price increase to maintain IRR (%)	-	0.82	0.86	2.31	0.82	0.41	1.72	0.82	0.23	1.54

Option B

The smallest impacts occur when wet scrubbers are used on the calciners and fabric filters are used on the grinders. Under full cost absorption, the decline in the return on investment is 1.5, 0.5, and 0.3 percent at the NSPS 1, NSPS 2, and NSPS 3 levels, respectively. Under full cost pass-through, prices would have to rise by 0.9, 0.4, and 0.2 percent at the NSPS 1, NSPS 2, and NSPS 3 levels of control, respectively. Furthermore, there would be no impact on total plant capital requirements at any of the control levels.

Option C

The most severe impacts would occur if electrostatic precipitators were used on the calciners and fabric filters were used on the grinders. Under full cost absorption, the decline in return on investment would range from 15 percent (NSPS 1) to 10 percent (NSPS 3). Under full cost pass-through, the increase in price needed to maintain the return to capital would range from 2.3 percent (NSPS 1) to 1.5 percent (NSPS 3).

Summary

As the preceding analysis showed, option B would be selected to comply with all of the NSPS control levels. The impacts on both rate of return and price are insignificant when this option is used. Because of the significantly higher capital and annual costs associated with option C, this option would not be selected in order to comply with any of the NSPS levels.

7.4.4 Summary of Economic Impacts on New and Modified Plants

Table 7-37 presents a summary of the control options that would be selected to control emissions from new and modified Florida and Western plants to meet the various NSPS control levels, based on the analyses in Sections 7.4.2

and 7.4.3. Option B, which consists of wet scrubbers on the dryers or calciners and fabric filters on the grinders, would be chosen for all plants to meet the NSPS 2 and NSPS 3 levels of control; it would be applied to the modified Florida and Western model plants at all three control levels. Option A, which consists of fabric filters on the dryers, calciners, and grinders, would be applied to the new Florida and Western plants to meet the stringent NSPS control level.

Table 7-37 also summarizes the price increase associated with each selected option necessary to maintain the return on investment at the baseline level. All of the required price increases are less than 0.9 percent. All of the increases estimated for the Florida model plants are under 0.2 percent.

Implementation of the NSPS control levels would not cause any adverse economic impact on the phosphate rock industry since all plants would have to meet the SIP level of control in the absence of an NSPS. The incremental cost of meeting the different NSPS levels is small enough that the profitability of the plants is not significantly affected. Hence, new plant construction or modification of existing plants would not be affected.

7.5 POTENTIAL SOCIOECONOMIC AND INFLATIONARY IMPACTS

Executive Order 12044 requires that the inflationary impacts of major legislative proposals, regulations, and rules be evaluated. The proposed NSPS would be considered a major action (thus requiring the preparation of an Inflation Impact Statement) if either of the following criteria apply:

(1) Additional annualized costs of compliance, including capital charges (interest and depreciation), will total $100 million within any calendar year by the attainment date, if applicable, or within five years of implementation.

(2) Total additional cost of production is more than 5 percent of the selling price of the product.

The NSPS for phosphate rock would not qualify as a major action by the second criterion, since the largest price increase was estimated to be less than 0.9 percent. The remainder of this section is devoted to estimating the total additional cost of compliance with the various NSPS control levels.

As shown in Table 7-8 in section 7.1.7, the industry expects to add 21,138 metric tons of capacity in the Florida region and to add 4,263 metric tons in the Western region. Most of this expansion will occur by 1983. The remainder will be added sometime after 1983 (see the last column in Table 7-8). To estimate the incremental cost of compliance for the industry, it was assumed that all of the increases to existing capacity would occur in 1985.

For each region, the planned total addition to capacity was apportioned into two subtotals, additional capacity from new plants and additional capacity from modifications to existing plants. These subtotals were then divided by the new model plant capacity and the increase in existing capacity of the modified model plant, respectively. In other words, the planned capacity additions were transformed into "model plant equivalents." Any fractions were rounded up to the nearest whole plant. Using this approach, it was estimated that expansion in the Eastern region would occur by building seven new Florida plants and by modifying four existing plants; in the Western region, four new plants would be built and one plant would be modified. The estimated compliance costs were based on the options that would be selected and which were presented in Table 7-37. The results are given in Table 7-38.

As Table 7-38 shows, the incremental cost of compliance with the NSPS 1 level of control is under $1 million, well below the threshold of $100 million specified in the Executive Order. For the NSPS 2 and NSPS 3 control levels, the maximum total costs are estimated at $930 thousand and $408 thousand, respectively. Since neither the annualized cost of compliance nor the estimated price impacts of the NSPS meet the criteria specified in the Executive Order, the proposed NSPS for the phosphate rock industry is not a major action and thus does not require the preparation of an Inflation Impact Statement.

No adverse socioeconomic impacts of the NSPS are anticipated. Because the impacts are insignificant, the expansion planned by the industry should not be affected. Thus, there will be no significant effect on regional employment and income.

Table 7-37. SUMMARY OF CONTROL OPTIONS AND RESULTING PRICE INCREASES, BY CONTROL LEVEL

	Florida				Western			
	New		Modified		New		Modified	
	Option	Price increase (%)	Option	Price increase (%)	Option	Price increase (%)	Option	Price increase (%)
NSPS 1	A	0.19	B	0.10	A	0.87	B	0.86
NSPS 2	B	0.13	B	0.05	B	0.38	B	0.41
NSPS 3	B	0.03	B	0.00	B	0.10	B	0.23

Table 7-38. POTENTIAL TOTAL INCREMENTAL COST OF COMPLIANCE WITH NSPS CONTROL LEVELS, 1983 (Thousands of dollars)[a]

Control level	Installed capital cost[b]	Total annualized cost[b]
NSPS 1	8,408	845
NSPS 2	0	930
NSPS 3	0	408

[a] Control options on which these estimates are based are given in Table 7-37. Control costs are taken from Tables 7-26, 7-27, 7-33, and 7-34.

[b] Costs calculated assuming that seven new plants are built and four existing plants are modified in the Eastern (Florida) region and that four new plants are built and one plant is modified in the Western region.

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RATIONALE FOR THE PROPOSED STANDARD

8.1 SELECTION OF SOURCE FOR CONTROL

The United States is the largest producer and consumer of phosphate rock in the world, producing an estimated 40 percent and consuming approximately 35 percent of the world's supply. Total U. S. production of marketable (beneficiated) phosphate rock in 1976 was about 50 million short tons, about eighty percent of which was from Florida.[1] About 70 percent of domestic consumption of phosphate rock is as fertilizer. The other major uses are in animal feeds, detergents, electroplating and polishing of metals, insecticides and medicines.

Demand for phosphate rock in the years 1985 and 2000, respectively, is projected to be 45 and 69 million tons for the United States and 162 and 387 million tons for the rest of the world.[2]

Phosphate rock deposits are found in 23 states. Florida, the leading producer for many years, furnished 80 percent of domestic production in 1976, with the remaining production occurring in Tennessee, North Carolina, and the western states.[3]

Figure 3.1, Chapter 3, shows the distribution of phosphate rock mines. In 1975, these mines ranged in size from 120,000 to 4.4 million tons per year and are located in urban, suburban and rural areas. From 1959 to 1973, the production of phosphate rock increased at an annual rate of about

6 percent, and is expected to increase at a rate of about 3 percent through the year 2000.[4]

The industry presents a significant potential contribution to air pollution due to large volumes of material handled. Any step in which the phosphate rock is handled in the dry state presents a potential for emission of particulate matter. Many of the processes employed in preparation of the rock; drying, calcining, grinding and pneumatic materials transfer, use large volumes of air which, at the process exhaust, contain suspended particulates. The environmental effects of particulate emissions have been investigated by the Environmental Protection Agency (EPA) and have been determined to pose a significant threat to public health and welfare.[5]

Section 111 of the Clean Air Act of 1970 extends authority to EPA to regulate emissions by developing standards of performance for new stationary sources based on the degree of emission limitation achievable through application of the best systems of emission reduction. Section 111(b), which allows EPA to limit emissions of pollutants for which air quality criteria have been prescribed, is appropriate for the phosphate rock industry, a major source of particulates. In a study performed by the Argonne National Laboratory for EPA in April 1975, phosphate rock grinders ranked fifteenth of 56 of the Nation's largest particulate source categories.[6] This same study concluded that setting standards of performance in 1975 would prevent the emission of 10,500 tons of particulate per year by 1985 and, on that basis, the source was ranked 24 out of 107 candidates for standards of performance. In another part of the study, phosphate rock dryers was ranked fourth highest of eighteen particulate source categories which require control systems with moderate energy consumption. The study showed that setting standards of performance for dryers in 1975 would prevent the emission of 3,800 tons of particulate per year by 1985.

The above characteristics of the industry, high growth rate, significant emissions and availability of control technology, underscore the need for standards of performance. The decision to develop standards of performance now rather than to postpone them for several years was influenced by EPA's recent regulatory activity in this industry. Standards of performance for the high growth fertilizer processes were promulgated on 6 August 1975. Effluent water standards for the industry were promulgated on 8 April 1974 and amended on 6 August 1975 for the mining and beneficiation processes. The phosphate rock production and fertilizer production segments of the industry are interdependent and it is difficult to consider one segment while ignoring the other. As a result, EPA engineers developed a level of expertise in the rock processing operations while studying the fertilizer operations. Similarly, the industry has developed a working knowledge of regulatory proceedings prescribed by the Clean Air Act. The expertise developed by these two factions would be diminished if standards development were postponed. Also, since any increase in phosphate rock mining will result in increased fertilizer production and visa versa, new sources in one area will ultimately result in new sources in the other. The industry should know what emission control measures will be expected in all areas of production, allowing them to plan costs more accurately and have some degree of confidence in the level of emission control that will be expected by regulatory authorities.

8.2 SELECTION OF POLLUTANTS AND AFFECTED FACILITIES

Operations which are considered as affected facilities are drying, calcining, ground rock handling and storage, and grinding. The bases for selection of these processing steps are 1) significant increase in future growth, 2) significant potential for emissions, and 3) availability of technology to insure significant reduction of emissions. Each operation will be discussed separately.

Drying is chosen as an affected facility largely because of the importance of this operation in preparing Florida rock for fertilizer manufacture. About 96 percent of the rock produced in Florida is dried. Dryers are also used to some extent in the other processing areas, usually for processing rock destined for shipping or manufacture of fertilizers. Since the future growth of fertilizer industries (estimated at 3 percent per year) is dependent on supplies of rock, it is likely that demand for additional dryers will parallel demand for additional fertilizer. Drying presents a potential for emission of particulate matter because of attrition of the rock in the dryer and the large volume of air which sweeps through the dryer and must be vented to the atmosphere. The magnitude of the potential for emissions can be estimated by considering a typical rock dryer, processing 250 tons of rock per hour, discharging 85,000 scfm. The average loading of particulate matter in the air stream is about 2 grains per standard cubic foot. The potential annual emission for such a dryer is about 5700 tons of particulate matter, assuming 90 percent operating factor and no control of emissions. As detailed in Chapter 4, technology is available to insure significant reduction in these emissions.

The potential emission of gaseous fluorides from rock dryers is not significant. This observation is supported by the experience of Tennessee Valley Authority (TVA) researchers.[7] In their experiments to determine the temperature at which fluorine volatilization begins, TVA heated phosphate rock samples to 932°F, 1112°F, 1292°F, 1472°F, and 1742°F for 30 minutes each. Chemical analyses of samples before and after heating showed fluorine volatilization only in the sample which was heated to 1742°F. Seven percent of the fluorine in that sample was volatilized. The lack of a fluorine emission problem is also evidenced by a study done by the Battelle Memorial Institute in a study of the fertilizer industry done for EPA[8] and (negatively) by the absence of any existing legal restriction on fluoride emission from phosphate rock dryers. For these reasons, rock drying is not a candidate for standards of performance governing fluoride emissions.

Calcining is also selected as an affected facility for emissions of particulates. The potential growth of this operation is substantial, since any new fertilizer installation processing North Carolina or Western phosphate rock will require a calciner. These two areas of the phosphate industry are likely to expand since the reserves in both locations are extensive and are not as yet developed to their potential. As a source of emission of particulate matter, a typical calciner processes 50 tons of rock per hour (tph), exhausting 45,000 dscfm of gases with a particulate loading of 2 grains per standard cubic foot. The potential annual emissions rate for such a calciner is about 3,000 tons, assuming a 90 percent operating factor and no emission control. Technology is available to permit significant reduction in the uncontrolled emissions rate.

Data on gaseous fluoride emissions from calciners are contradicting. Two reports[9,10] indicate that the temperature of calcination is insufficient to drive off gaseous fluorides. However, one operator reports finding 0.002 pounds of gaseous fluorides in his calciner exhaust per ton of rock processed by his calciner.[11] This level appears relatively minor considering that fluorides emission standards for the related phosphate fertilizer industry permit a range of 0.01 to 0.2 lb/ton of phosphorous pertoxide (P_2O_5) feed for units of comparable capacity to phosphate rock calciners.

A fluoride standard is not recommended for calciners because emissions of gaseous fluorides from calciners is believed to be very small, if indeed present at all. Moreover, the recommended particulate standard will result in significant reduction of emissions of particulate fluorides. Also, a standard for fluorides would discourage the use of dry collection devices, such as fabric filters, in favor of scrubbers. Fabric filters are generally recognized as being superior to scrubbers for control of particulate emissions, and have no water pollution potential.

Oil-fired dryers and calciners also have a potential for emitting sulfur oxides when high sulfur residual fuel oils are burned. However, phosphate rock typically contains about 55 percent CaO which tends to react with the sulfur oxides, reducing emissions of this pollutant in the off-gases. Though data on sulfur oxide emissions from phosphate rock dryers and calciners are sketchy, one operator of a phosphate rock calciner reports only 0.04 to 0.08 parts per million (ppm) SO_2 in exhaust gases when burning No. 6 fuel oil containing 3 percent sulfur.[12] With no removal of SO_2 in the calciner, SO_2 in the exhaust gases would be about 1,000 ppm indicating an SO_2 removal efficiency of greater than 99 percent. At least one patent has been obtained for a system using phosphate rock as a scrubbing medium for sulfur oxides.[13] A standard for emissions sulfur oxides is not recommended for phosphate rock dryers or calciners.

The grinding operation is selected as an affected facility for particulate emissions. Projected growth of the grinding operations can be expected to parallel the growth of fertilizer production. The potential for contribution to air pollution is substantial; a typical milling installation grinds 50 tons of rock per hour, exhausting 5,400 scfm of gases with a particulate loading of 2 grains per standard cubic foot before emission control. The annual emissions potential for such a unit is about 300 tons per year, assuming 90 percent operating factor and no attempt at emission control. Technology is available for significant reduction of this potential emission.

It should be noted at this point that considerable advances have recently been made in wet grinding. If this procedure is adopted, air pollution in the Florida segment of the industry could be drastically reduced since the rock drying step could be eliminated, and wet grinding presents no air pollution potential.

The final process which is selected as an affected facility is ground rock handling and storage. The growth potential of these operations is of course substantial, since any new installation will handle and/or store ground rock. The emissions potential for these operations is very difficult to quantify, since systems for the handling and storage of rock are highly individualistic and often complex, reflecting the plant operator's judgement as to what is most suitable for the particular installation. As a result, there is no system which can be called typical. However, there are available methods of conveying, storing, crushing, and size-classification which would insure significant reduction of fugitive emissions. As noted in Chapter 3, certain types of equipment (screw conveyors, pneumatic systems, etc.) are common.

Mining, beneficiation, thermal defluorination, elemental phosphorus production and nodulizing are not selected as affected facilities. The deposits in Florida, North Carolina, and Tennessee are of such a character as to pose little air pollution threat in the mining step, in that they are located in moist earth. Mining operations at Western deposits located in arid country can be dusty. However, these operations account for only about 2 percent of the nation's production and are in very rural locations. A program to develop standards specific to this small portion of the industry is not warranted. Beneficiation presents no significant potential for air pollution since the operations involve slurries of rock in water. Thermal defluorination, elemental phosphorus production, and nodulizing are not selected as affected facilities because they fail to meet the criterion of significant growth potential.[14] Operators interviewed generally concurred in the opinion that substantial increase in production capacity was unlikely in the foreseeable future.[15]

8.3 SELECTION OF THE BEST SYSTEM OF CONTINUOUS EMISSIONS REDUCTION CONSIDERING COST

The control options for each of the affected sources are summarized in Table 8-1. While the efficiency of fabric filter collectors is relatively unaffected by the size distribution of the particles, particle size affects the performance of scrubbers and ESPs substantially, especially for fine particles such as those emitted by phosphate rock plant facilities. The fabric filter is capable of removing at least 99 percent of particulate emissions from dryers and calciners while the low energy scrubbers typically used throughout the industry are capable of an efficiency between about 94 and 97 percent. However, with proper design, both the scrubber and the ESP are capable of achieving the high efficiencies attained by the fabric filter. This is accomplished by designing the scrubbers for high energy and liquid/gas ratios, and designing the ESPs for high area/gas volume ratios.

Baghouses are not currently used to control emissions from phosphate rock dryers and calciners. The industry is concerned that baghouses may blind or be overheated when treating the hot, moist stack gases from dryers and calciners. However, EPA's analysis shows that these problems are resolvable, and that there are no apparent technical problems which would preclude the use of baghouses for control of dryer or calciner emissions. The 1974 EPA study, Control of Particulate Emissions from Phosphate Rock Dryers, by A. Lindsey and R. Segars, outlines examples of baghouse installations utilized in applications similar to the phosphate rock dryers and calciners. The problem of moisture condensation has been resolved in other industries by maintaining sufficient temperature difference between wet and dry bulb temperature control relative humidity. The problem of overheating is avoided by maintaining exhaust gas temperatures in the acceptable temperature range of the bag fabrics. Other factors, such as acidity of the gas stream,

Table 8-1 AFFECTED FACILITIES AND CONTROL OPTIONS

Affected Facilities	Control Options
1. Dryers	a) Baghouse b) Wet electrostatic precipitator c) Scrubber
2. Calciners	a) Baghouse b) Wet electrostatic precipitator c) Scrubber
3. Grinders	a) Baghouse b) Wet electrostatic precipitator c) Scrubber
4. Ground rock handling and storage	a) Closed conveyors and silos vented to scrubber b) Closed conveyors and silos vented to baghouse c) Closed conveyors and silos vented to electrostatic precipitator

adsorption, adhesion and electrostatic properties of the particles which could adversely affect the performance of a baghouse can generally be solved by proper selection of the fabric for the bag.

The cost of the alternative control systems depends on the performance and the associated design of the system. Tables 8-2 through 8-4 summarize the costs of the control options at various collection efficiencies, ranging from the high efficiency achieved by the fabric filter, high energy scrubber and high efficiency ESP to the lower efficiencies attained by the low energy scrubber and ESP. These costs were derived from information presented in Tables 7-15, 7-13, and 7-19 respectively, for dryers, calciners and grinders. The reader is referred to the discussion of Chapter 7.2 for detail of the parameters considered when developing the cost data.

The installation costs for a scrubber are consistently lower than the other two control systems for each of the processes considered. Wet electrostatic precipitators are the most expensive device to install, and

Table 8-2. DRYER CONTROL COSTS COMPARED TO COSTS FOR A DRYER MEETING EXISTING REGULATIONS WITH A SCRUBBER

Level of Control (Percent)[b]	Control device	Increased costs over a scrubber meeting typical SIP's (thousands of dollars)		Increased annualized costs in terms of ¢ per ton of production
		Installed	Annualized[a]	
99.3	Fabric Filter	318	22	2
99.3 (A/V=1700)	Wet Electrostatic Precipitator	1,510	378	39
98.7 (A/V=900)		946	252	26
97.9 (A/V=600)		654	187	19
95.5 (A/V=260)		357	121	12
99.3 (ΔP=25")	Venturi Scrubber	0	67	7
98.7 (ΔP=15")		0	33	3
97.9 (ΔP=10")		0	17	1
95.5 (ΔP=5")		0	0	0

[a] Includes direct operating costs and annualized capital charges.

[b] Scrubbers and ESPS are assigned a range of efficiency depending on the operating parameters. Operating parameters for the scrubber are pressure drop, ΔP, in inches of water, and an assumed liquid to gas ratio (L/G) of 12 gal/1000 ACF. For the ESP, the specified parameter is area to gas volume ratio (A/V), in ft^2/1000 ACFM.

Table 8-3. CALCINER CONTROL COSTS COMPARED TO COSTS FOR A CALCINER MEETING EXISTING REGULATIONS WITH A SCRUBBER

Level of Control (percent)[b]	Control device	Increased costs over a scrubber meeting typical SIP's (thousands of dollars)		Increased annualized costs in terms of ¢ per ton of production
		Installed	Annualized[a]	
99.0	Fabric Filter	329	18	5
99.0 (A/V=1200)	Wet Electrostatic Precipitator	1,255	321	95
97.4 (A/V=500)		589	172	51
95.5 (A/V=260)		370	124	37
94.5 (A/V=200)		310	110	33
99.0 (ΔP=27")	Venturi Scrubber	0	71	21
97.4 (ΔP=15")		0	26	8
95.5 (ΔP=10")		0	8	2
94.5 (ΔP=8")		0	0	0

[a] Includes direct operating costs and annualized capital charges.

[b] Scrubbers and ESPS are assigned a range of efficiency depending on the operating parameters. Operating parameters for the scrubber are pressure drop, ΔP, in inches of water, and an assumed liquid to gas ratio (L/G) of 12 gal/1000 ACF. For the ESP, the specified parameter is area to gas volume ratio (A/V), in ft^2/1000 ACFM.

Table 8-4. GRINDER CONTROL COSTS COMPARED TO COSTS FOR A GRINDER MEETING EXISTING REGULATIONS WITH A FABRIC FILTER

Level of Control[c] (percent)	Control device	Increased costs over a fabric filter meeting typical SIP's (thousand dollars)		Increased annualized costs in terms of ¢ per ton of production
		Installed	Annualized[a]	
99.9	Fabric Filter	0	0	0
99.6 (ΔP=16")	Venturi Scrubber	-46[b]	56	62
99.5 (ΔP=15")		-46[b]	56	62
99.2 (ΔP=10")		-46[b]	56	61
98.7 (ΔP=6")		-46[b]	55	61

[a] Includes direct operating costs and annualized capital charges.

[b] Negative numbers indicate a cost savings.

[c] Scrubbers are assigned a range of efficiency depending on the operating parameters. Operating parameters for the scrubber are pressure drop, ΔP, in inches of water, and an assumed liquid to gas ratio (L/G) of 12 gal/1000 ACF.

baghouses consistently have medium installation costs. When considering the total annualized costs, however, fabric filters become the least expensive and wet electrostatic precipitators the most expensive.

Based on the average June 1975 selling price of $18.00/ton for phosphate rock, the industry would experience additional (above those incurred under the SIP regulations) dryer costs amounting to about 0.4 percent of the product price when high energy scrubbers are used to achieve emission control equal to that attained by the baghouse. Similarly, the annualized cost of calciners would increase by 1.2 percent of the product price to attain baghouse control efficiency. If the industry chooses baghouses to control emissions, the additional control costs for the dryer and calciner would be 0.1 and 0.3 percent of the product price, respectively. Utilization of electrostatic precipitators would create additional control costs for the dryer and calciner of 2.2 and 5.3 percent of the product price, respectively. For grinders, the lowest annualized emission control costs are attained when the baghouse (the prevailing system used to meet existing SIP regulations) is employed.

If baghouses or scrubbers are utilized, none of the levels of control discussed in this chapter will cause a significant impact on the profitability of a typical new or modified phosphate rock plant. However, the impact on profitability of the plant would be significant if the more costly electrostatic precipitators were employed. It is estimated that installation and operation of high efficiency electrostatic precipitators would require product price increases of 1.9 and 5.2 percent to maintain return on investment expected from an SIP-controlled new Florida plant and new western plant, respectively. By contrast, meeting more stringent control standards by utilization of high energy scrubbers would require product price increases of 0.3 and 1.0 percent to maintain return on investment expected from an SIP controlled new Florida plant and new western plant, respectively. The additional cost of meeting more stringent standards using baghouses would be negligible. See Chapter 7 for more detail on the economic impacts of the levels of control considered in this document.

The environmental impacts are least when using fabric filters to control emissions from phosphate rock dryers, calciners, grinders and ground rock transfer systems. This is because aqueous effluents are nonexistent and energy requirements are minimal for fabric filters. Discharge of solid wastes, including radiochemical pollutants, is also least when using fabric filters because the particulate collected can often be returned to product inventories. However, the increase (over prevailing controls) of solid materials and wastewaters produced while achieving compliance using scrubbers on wet ESPs is insignificant in comparison with 1) the large volumes of process wastes, and 2) the total wastes already collected by prevailing controls to meet existing state regulations.

After evaluation of all cost and environmental impacts, a fabric filtration system or a high energy venturi scrubber was determined to be the best technological system of continuous emission reduction for each of the affected facilities discussed in this document. However, the high efficiency electrostatic precipitator (ESP) is judged to be equally as effective as the baghouse or high energy scrubber in terms of emissions reduction capability. The proposed standards may, therefore, be based on the use of any of the three alternative controls. Cost considerations would favor the use of the baghouse or high energy scrubber over the ESP, and the incremental nonair quality adverse impacts associated with the alternative controls may marginally favor the use of the baghouse over the scrubber and ESP. Finally, the experience of the industry in using scrubbers extensively to control emissions from dryers and calciners would favor the use of scrubbers at future installations to minimize technical uncertainties associated with equipment installation and operation.

Declaration of the fabric filter or the high energy scrubber as the best system of emission reduction does not preclude the use of other systems which might also meet a proposed standard. The operator may select for use any other system of equal emissions reduction capability and which is also environmentally acceptable. This would include any of the three options discussed here. However, due to cost considerations, it is not expected that the ESP would be utilized at any of the affected facilities. The industry historically prefers to use the wet scrubber to control dryer and calciner emissions, and the baghouse for grinders. This trend would be expected to continue under the proposed standards, although use of high energy scrubbers would be a more costly alternative for achieving compliance in most situations.

8.4 SELECTION OF THE FORMAT

In accordance with the language of Section 111 of the Clean Air Act, the standard must reflect the degree of emissions limitation attainable by the best system of emissions reduction. Theoretically, the parameter which best expresses the degree of emission limitations attainable is control efficiency. Since control efficiency is a function of particle size, the standard could be posed as a specified removal efficiency requirement for various particle size ranges in the exhaust stream. The imposition of control efficiency is equitable in the sense that all operators must provide equivalent degrees of removal regardless of the uncontrolled emission rates. Implementation would require costly and cumbersome performance test requirements, including measurement of quantity and size of particulates entering and leaving the control device to assure compliance. Moreover, a format utilizing control efficiency as the enforceable element of the regulation would require a demonstration that the mandated levels of control are achievable with the best system of emissions reduction. While there is ample data for estimating the efficiency of the various alternative control methods, only limited test data is available to validate definitely the attainable efficiencies in phosphate rock applications. Predictions for the efficiencies have been included in this document for purposes of estimating air quality impacts only. These predictions were made using particle size distribution data and mathematical performance models or fractional efficiency data for the various alternative controls, and do not constitute a sufficient basis for the development of a control efficiency standard.

Another direct means of regulating control technology involves the operating and design standard. This format consists of specifications for equipment and operating procedures consistent with the best system of emissions reduction. Compliance with the operating and design standards would be assured by periodic on-site inspection to ascertain that equipment is being utilized in the prescribed manner. The equipment standard was not considered as a candidate format because of provisions in the Act which favor application of emissions limits when feasible to prescribe and enforce. Moreover, there are significant drawbacks in the application of the equipment standard. First, the equipment standard is overly restrictive in that it discourages the use of alternative control designs and the development of improved control technologies. Second, the equipment standard is generally difficult to prescribe and implement.

The two most frequently employed options for use as the format of a particulate standard are a concentration standard or a mass per unit of feed standard. For either format, the standard limit depends on the level of emissions which are to be controlled. For example, a baghouse operating at 99.5% efficiency will attain a control limit of .01 gr/dscf for a 2 gr/dscf emissions loading, while a control limit of .02 gr/dscf would be possible for a stream emitting 4 gr/dscf. This is unlike the formats involving efficiency and equipment specifications, which are determined independent of the particulate loading of the uncontrolled emissions stream. Thus, for the concentration or process weight standard, there is some question concerning the definition of the emissions stream needing control. Should the emissions limitation achievable by best technology be determined for an "average", representative, typical or worst case emission stream? To assure that all industry can meet the standard, it would be necessary to base the standard on the most adverse emissions control problem which occurs. However, if the emissions stream is highly variable in nature and pollutant emissions, the latter standard could be met at many sources by application of less than "best" technology. Such a result would not seem to be consistent with the apparent intention of Section 111 of the Clean Air Act. One means of mitigating this problem is to establish separate emissions limits for distinguishable source sub-categories emitting pollutant levels. For example, the emission standards for boilers are specified in terms of fuel type utilized (coal, oil, and gas).

A logical subcatagorization scheme for emission sources in the phosphate rock industry would be based on distinguishable feed ores. Although emissions concentrations and mass per unit feed rates are known to vary substantially for grinders, dryers and calciners depending on the type of feed (e.g., pebble rock is known to produce greater emissions than other beneficiated ores during drying), it is not clear if separate standards should be developed for the various categories of ore feeds. A major problem concerning this approach is the fact that other differences in the ore (e.g., moisture content, clay content) also affect the emission rate significantly. The actual significance of the various ore characteristics on emissions levels is not specifically known. In addition, the categorization of ore feeds is further complicated by the fact that operators frequently blend different ore types as they are introduced to the various plant processes. Therefore, it would not appear feasible to establish separate emissions standards for ore feed categories at this time. Consequently, the emissions standard should reflect the level of control attainable for representative conditions producing the greatest emission levels.

The next issue in the format development is whether the emission limitation achieved by the best system of emissions reduction (for the characterized emission stream) is best reflected by a concentration or mass per unit feed format. Either format may be used with the same control result if the two units are related consistently to each other. Figures 8-1 to 8-3 show there is no consistent relation for dryers, calciners, and grinders. That is, compliance with a concentration standard does not guarantee compliance with a particular level of mass emissions, or vice versa. Thus, either the concentration format or the mass emissions per unit feed format must be chosen as the best representation of the system attaining maximum emissions reduction. The advantages of the mass emissions standard are as follows:

1. The mass emissions format is consistent with existing applicable state standards.
2. The mass emissions format relates directly to the total quantity of emissions discharged to the atmosphere.
3. The mass emissions format is more equitable. The degree of emissions permitted are related to the amount of product processed.

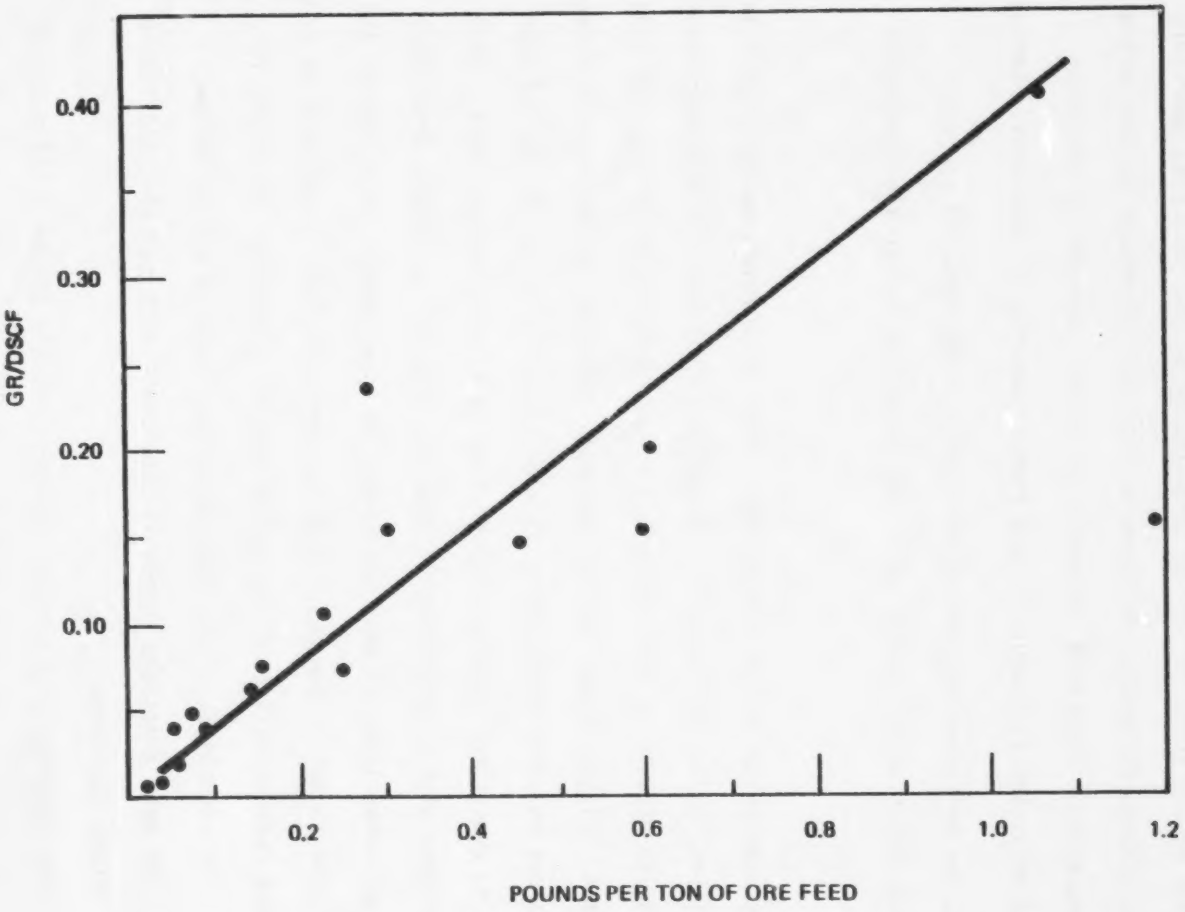


Figure 8-1. Concentration Versus Mass Loadings of Particulate Emissions from Phosphate Rock Dryers.

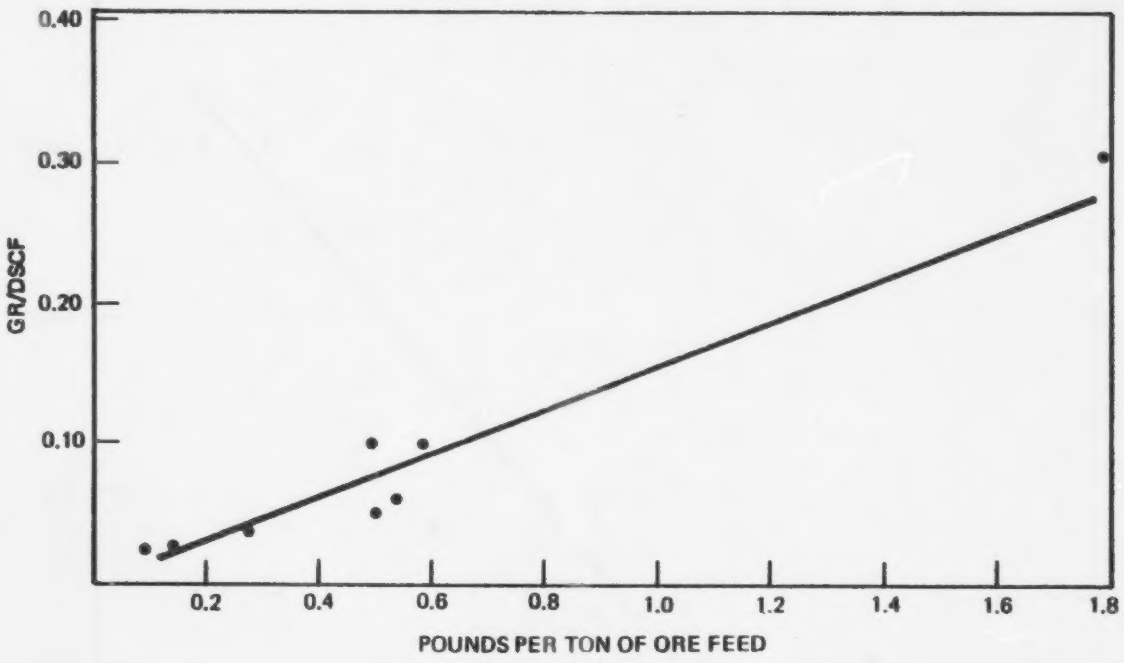


Figure 8-2. Concentration Versus Mass Loadings of Particulate Omissions from Phosphate Rock Calciners.

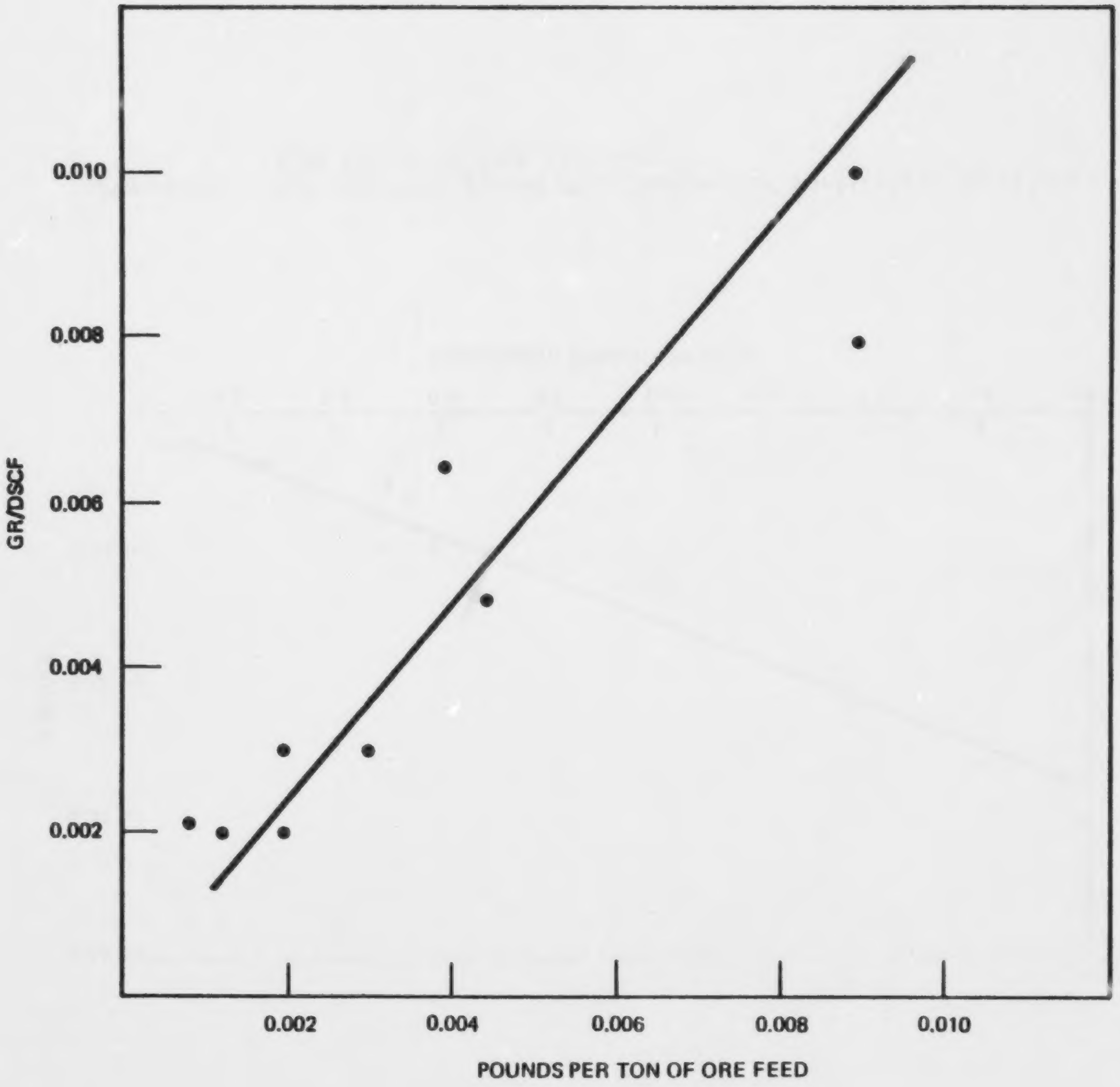


Figure 8-3. Concentration Versus Mass Loadings of Particulate Emissions from Phosphate Rock Grinders.

4. The mass emissions format does not discourage use of controls or exhaust gas systems which affect exhaust gas volume (e.g., a more efficient burning of fuels for heat in the calciner at lower air flows). Thus this format would permit the concentration of the exhaust gas stream to increase, while the system would remain in compliance in terms of total emissions per unit of useful product.
5. This format ensures that the standard is not circumvented by dilution, or that the standard is not achieved merely because of high volume flow in the exhaust design. Attainment of the standard is not dependent on the exhaust system but on the overall control of emissions generated by the process.

The advantages associated with the concentration standard are generally related to practical considerations:

1. The concentration standard is more easily enforced since compliance is more easily verified.
2. The concentration standard avoids judgments of equity in defining feed rate or process weight. By contrast, mass emissions standards involve issues such as 1) whether the process weight should be expressed in terms of feed rate or rate of useful product produced and 2) whether the quality of the product should affect the allowable emissions limits.

Based on a comparison of advantages of the alternative formats, it has been determined by EPA that the mass per unit feed format is the more equitable and logical approach for the standard development. The process weight format is appropriate for dryers, calciners and grinders. However, a mass emissions or concentration format is not appropriate for ground rock handling systems because: 1) emissions from these systems vary greatly due to appreciable differences in design from plant to plant, and 2) a substantial portion of the potential emissions from ground rock handling systems are fugitive emissions and cannot feasibly be measured. Therefore, a visible emission standard is the only format appropriate to material handling facilities.

8.5 SELECTION OF EMISSIONS LIMITS

The proposed emission limits are based on the emissions levels attainable by application of the best demonstrated system of emission reduction, considering costs, and environmental, economic and energy impacts. This system may be defined as either the fabric filter or the high energy venturi scrubber. However, the high efficiency electrostatic precipitator is judged to be equally effective in terms of emissions reduction capability. The proposed emissions limits may, therefore, be based on the use of any of the three alternative controls.

In selecting emission limits it is important to recognize that the levels of control achievable by the control alternatives discussed in Chapters 6 and 7 are not to be interpreted as recommended emission standard limits. Rather, these control levels were established as representative emissions levels achievable by alternative control systems operating on typical uncontrolled process emissions streams. These levels were selected for the purpose of estimating environmental and cost impacts which would occur if they were attained as control targets. The levels are in the neighborhood of that expected if the alternative systems would be used and may, therefore, be considered somewhat representative of the different control systems in the assessments. The specific determination of an appropriate standard is based primarily on source test data. The impact of this standard may be determined by relating the control level of the standard with the appropriate impact analysis of the alternative control systems in Chapters 6 and 7. The emission limits proposed for each of the sources (dryers, calciners, grinders, material handling equipment) are discussed below.

8.5.1 DRYERS

Particulate emissions were measured from a rotary bed and fluid bed dryer at two phosphate rock plants. Each of the dryers was used to process Florida pebble rock. The pebble rock is considered to present the most adverse conditions for control of emissions from dryers because it receives relatively little washing and enters the dryer containing a substantial percentage of clay. Based on previous discussion, both types of dryers, the rotary and the fluid bed, are considered to generate equivalent emissions levels.

At Facility A, an oil-fired rotary dryer processes from 220 to 440 TPH of phosphate rock, depending on the moisture content and type of rock processed. The dryer was tested during normal operation using EPA Method 5. In one series of tests conducted by EPA, only Florida pebble rock was dried. In another set of tests conducted by the operator, pebble rock was processed in the first operator test and flotation cell concentrates were tested during the second test. The dryer emissions are treated by a venturi scrubber operating at a pressure drop of 18 inches of water.

Results of the tests of Facility A are shown in Figure 8-4. Emissions from the venturi scrubber averaged .039 lb/ton and .038 lb/ton for the EPA

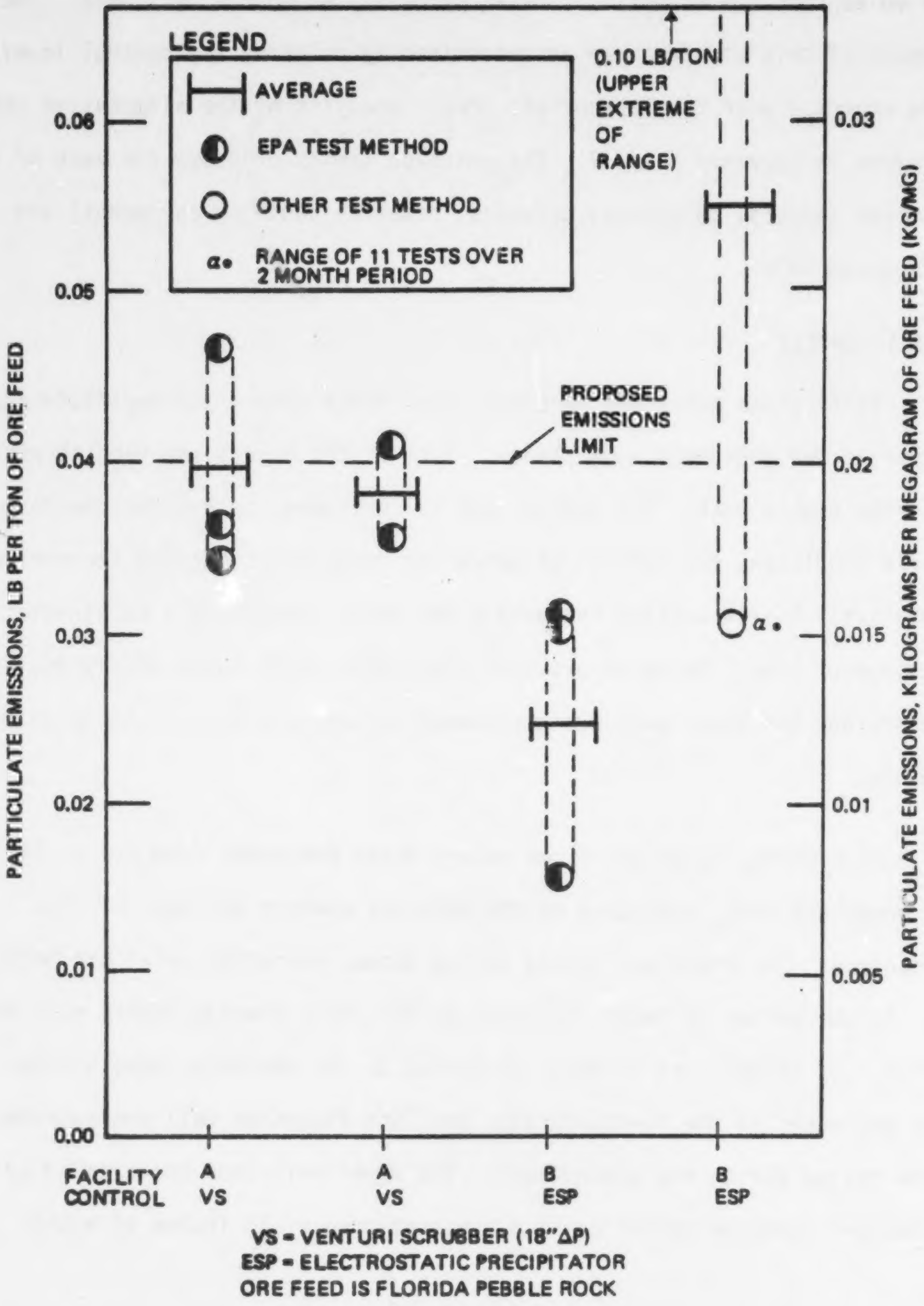


Figure 8-4. Particulate Emissions from Well-Controlled Phosphate Rock Dryers.

and operator tests, respectively. Individual test sample results ranged from 0.034 to 0.47 lb/ton.

At Facility B, an oil-fired rotary dryer and an oil-fired fluid bed dryer are operated in parallel to dry Florida pebble rock at an average production rate of 330 TPH and 165 TPH, respectively. Emissions from each dryer are partially controlled by a separate impingement scrubber. Emissions from the scrubber are combined and treated by a two-stage wet electrostatic precipitator (ESP). The ESP, which presently operates at a plate area to gas volume ratio of about 400 ft^2/1000 ACFM, was designed to treat approximately twice the volume of air which is actually processed. EPA measured emissions from the ESP using EPA Method 5 while the operator measured emissions employing the Florida Department of Pollution Control Method.

The results of the tests of Facility B are shown in Figure 8-4. Emissions from the ESP averaged .025 lb/ton and .054 lb/ton for the EPA and operator tests. Individual test sample results ranged from .014 to .10 lb/ton.

The test results (Facility A) show that the venturi scrubber is capable of achieving emission levels of .039 lb/ton from phosphate rock dryers emitting high loadings of particulate matter comprised of relatively fine particles. The high efficiency ESP and scrubber system (Facility B) demonstrated even lower emission levels during tests conducted by the EPA (.025 lb/ton). At Facility A, test results[19] revealed the scrubber achieved 99.2% efficiency.

It is estimated that a baghouse control device could achieve 99.4% efficiency when treating the same emissions loading and particle size distribution.[a] The additional degree of control to achieve the same performance (99.4%) as a baghouse can be attained by a scrubber by increasing its energy input. The actual energy needed to achieve a given emissions level will vary depending on the characteristics of the emissions stream. At Facility A, where the emissions are considered representative of the most adverse control problem in the industry, it is estimated (based on an empirically calibrated mathematical model of venturi scrubber performance)[16] that increasing the scrubber pressure drop to 25 inches of water would achieve control equivalent to a baghouse, resulting in a reduction of emissions levels by about 20 percent below that measured. Therefore, it is EPA's judgement that an emissions limit of 0.04 lb/ton reflects the emissions level attainable by the best system of emissions reduction (either a high energy scrubber or a baghouse), and that these technologies are available and may be applied to meet this control level without cost hardship to the phosphate rock industry.

For a typical size dryer (250 TPH) the recommended standard would limit emissions to approximately one-sixth of the rate permitted under the most stringent state standard.

8.5.2 CALCINERS

Particulate emissions were measured from fluid bed calciners at two phosphate rock plants. Each of the calciners are used to process western phosphate rock. Western rock may be considered to produce more adverse

[a] The efficiency of the baghouse control is estimated by applying a fractional efficiency curve (efficiency versus particle size) to the particle size distribution of the dryer emissions. The efficiency curve was developed from test data acquired from the Particulate Pollutant System Study conducted by the EPA, and is representative of a baghouse performing under control conditions similar to those produced by phosphate rock dryers.

conditions for emissions control from calciners because it receives less cleaning during beneficiation than other ore types. In addition, one of the two calciners processes a mix of both beneficiated and unbeneficiated rock, lending to a still more adverse control problem.

At Plant C, an oil-fired fluid bed calciner removes moisture and organics from western beneficiated rock. The calciner unit is designed for 70 TPH capacity but processes 80 TPH by using rock feed which has been partially dried. The calciner emissions are treated by a venturi scrubber operating at a pressure drop of 12 inches of water. Emissions measurements were performed by both EPA and the operator using EPA Method 5.

Results of the tests at Plant C are shown in Figure 8-5. Emissions from the venturi scrubber averaged .14 lb/ton for the EPA tests and .24 and .136 lb/ton for the operator tests. Individual test sample results ranged from .09 to .31 lb/ton.

At Facility K, an oil fired fluid bed calciner processes blends of beneficiated and unbeneficiated rock at the rate of 25 TPH. The calciner emissions are controlled by an Entoleter scrubber operating in the range of pressure drop 23 to 30 inches of water. Emissions measurements have been performed by the operator using EPA Method 5 as part of the testing requirements imposed by the State of Idaho.

Results of the tests at Facility K are shown in Figure 8-5. Emissions from the Entoleter scrubber averaged .10 lb/ton when blends consisting of at least one-third unbeneficiated rock were processed and the scrubber was operated at 30 inches of water pressure drop. When over one-half of the feed was unbeneficiated rock, and the scrubber was operating at 23.5 inches water, emissions levels were measured at .08 lb/ton.

The overall test results show that a venturi scrubber operating at low energy (12 inches water) is capable of achieving emissions levels of .24

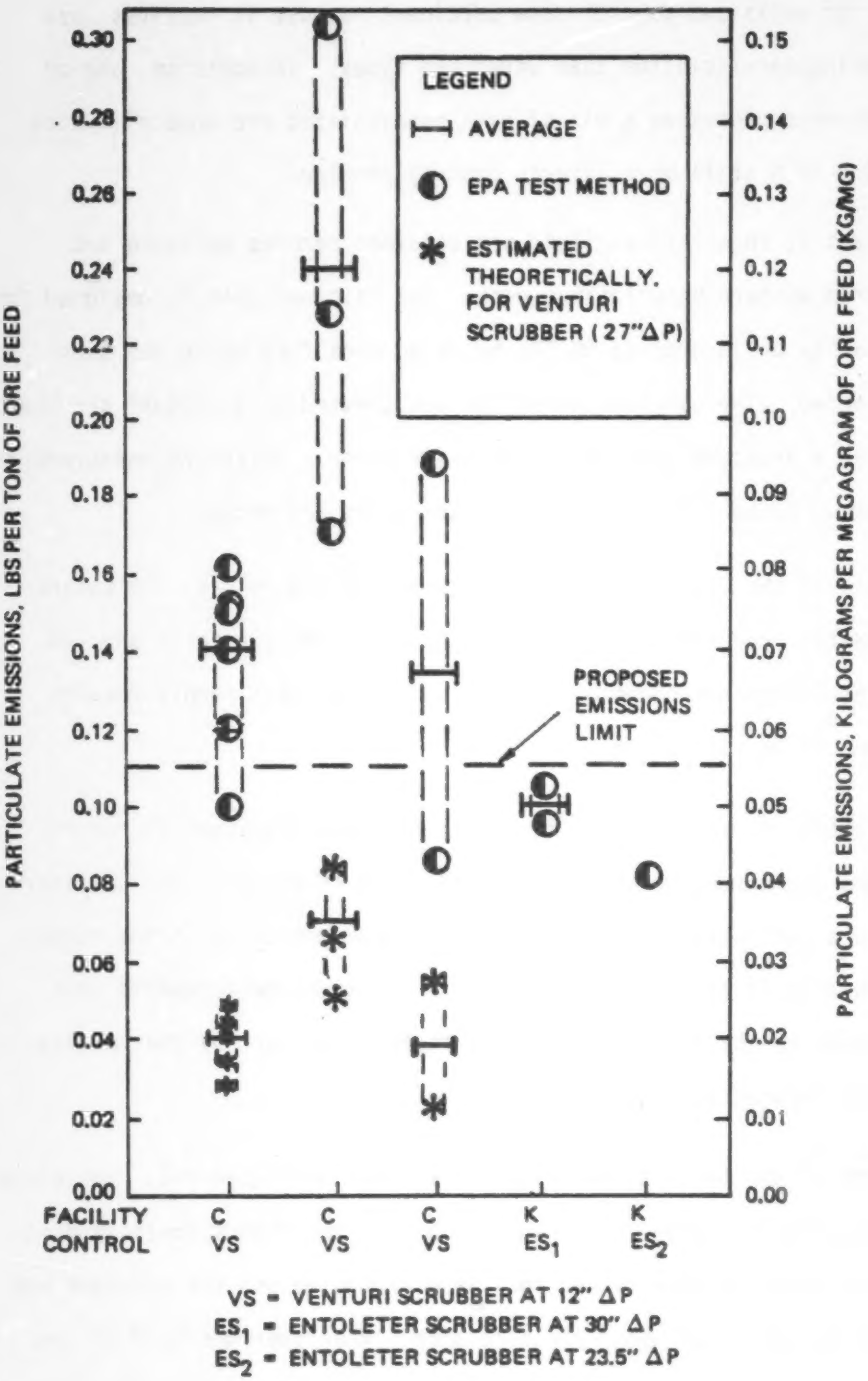


Figure 8-5. Particulate Emissions from Well-Controlled Phosphate Rock Calciners.

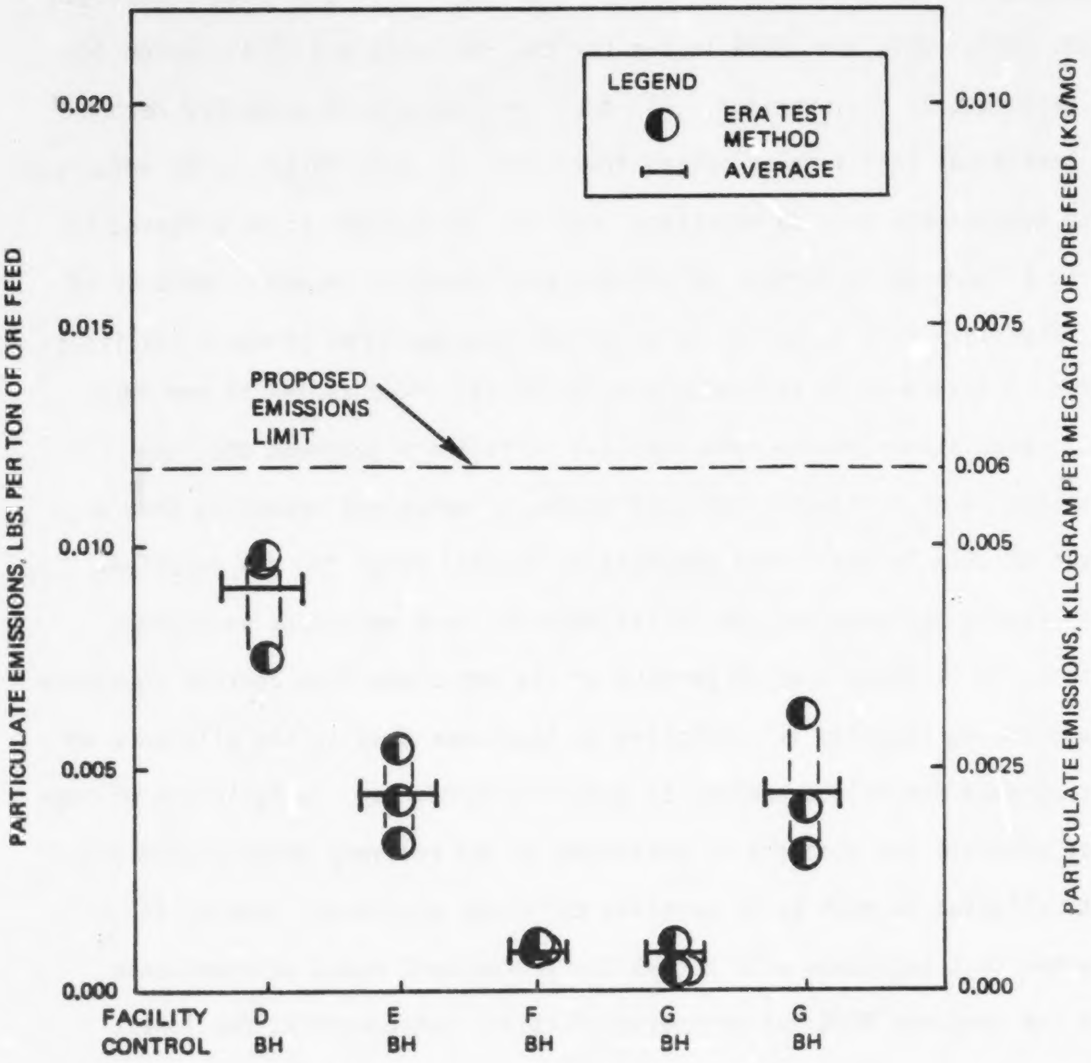
lb/ton and less from phosphate rock calciners processing western beneficiated rock, and that an Entoleter scrubber operating at relatively high energy (23 to 30 inches water) is capable of achieving emission levels of .10 lb/ton from calciners generating higher levels of particulate emissions. These emission levels are appreciably lower than those now permitted by the most stringent State regulations (.6 lb/ton in Florida). At Facility K, the Entoleter scrubber, operated at a pressure drop of 23 to 30 inches of water is estimated to achieve the control level attainable by the best system of emissions reduction.[17] At Facility C, the particulate removal efficiency of the venturi scrubber can be improved to the level attainable by the baghouse (99.0%) by increasing the energy input. Estimates of the emission levels which would be anticipated from the venturi scrubber when operated at higher pressure drops are shown in Figure 8-5. The estimates are made by adjusting the measured emissions at the 12 inch pressure drop to reflect the performance of the scrubber at the energy level (27 inches ΔP) creating the best system of emissions reduction. The adjustments are made using a calibrated model which predicts scrubber performance at various energy inputs.[16] At the appropriate energy level, the high energy scrubber is equivalent to the fabric filter in terms of removal efficiency. Both the fabric filter and high energy scrubber are available technology which may be applied to control emissions from calciners without cost hardship to the phosphate rock industry. As shown in Figure 8-5, the emissions level attainable by the high efficiency wet scrubbers (or a baghouse) when controlling the more adverse loadings expected from calciners is 0.11 lb/per ton of rock feed or less. It is EPA's judgement that this emission limit reflects the emission level attainable from calciners when the best system of emissions reduction (either baghouse or the venturi scrubber) is employed.

8.5.3 GRINDERS

Particulate emissions were measured from four grinders. The ore feed is essentially dry when entering the grinders and is typically ground to a fine powder. The discharge air stream from grinders consists of the purge tramp air entering the system and the quantity of this air flow is dependent primarily on the design of the grinding circuit rather than the capacity of the mill. Airflow varies substantially among grinders, and the amounts of exhaust air measured from the four facilities reflect the range of typical variations expected in the industry. The test data support the general conclusion apparent from industry data that emissions variations are not clearly related to factors such as fineness of grinding, type of ore, or process variables (see Table 4-4). Given the difficulties in defining any specific grinding system which produces a more adverse emissions control problem than another, the grinders tested were selected to represent a wide variation of exhaust air rates, grinder designs, capacities, and product feeds. Table 8-5 describes the various grinder facilities incorporated in the testing program.

Table 8-5. CHARACTERIZATION OF CONTROLLED GRINDERS SELECTED FOR TEST

Facility Designation	Type of Mill	Capacity, TPH	Exhaust Air, dscfm	Ratio, $\frac{\text{dscfm}}{\text{TPH}}$	Average exhaust concentration gr/dscf	Average mass emissions, lb/ton
D	ball	124	13600	110	.0098	.0088
E	roller	35	2708	78	.0065	.004
F	roller & ball	77	6645	87	.002	.001
		77	5133	67	.0028	--
G	ball	80	4124	52	.0021	.0009
		52	5568	108	.0049	.0045



BH = BAGHOUSE

Figure 8-6. Particulate Emissions from Well-Controlled Phosphate Rock Grinders.

Emissions from each of the four grinder facilities are treated with fabric filters. Figure 8-6 illustrates the results of emissions tests conducted at each of the facilities. Emissions from the baghouses averaged .0088, .004, .001, and .0009 lb/ton for the EPA tests and .0045 lb/ton for the test made by the operator. All tests were performed using EPA Method 5. Individual test samples varied from .0006 to .0097 lb/ton. The emissions tests demonstrate that an emissions level of .01 lb/ton can be achieved by fabric filters for a variety of grinder applications. However, because of the relatively wide variation in emissions expected from grinders (as illustrated in Figure 8-6), and because of potential inaccuracies in ore feed rates associated with the test results, it is EPA's judgment that the emissions level reflecting the best system of emissions reduction should be set at .012 lb/ton. This potentially liberal level for the emissions limit should not preclude the installation of best emissions reduction systems. It is noted that 80 percent of the emissions from current phosphate rock grinding capacity is controlled by baghouses despite the allowance of less capable control technology by existing standards. Installation of baghouse controls for grinders is motivated by the recovery value of the product collected as much as by existing emissions standards. Hence, it is expected that baghouses will become the predominant means of compliance with the proposed NSPS for grinder facilities, consequently, the lowest emission levels will tend to be achieved despite the potentially liberal emissions standard.

For typical sized grinders of 50 TPH capacity, the recommended standard would limit emissions from grinders to approximately 2 percent of the rate enforced under the most stringent state regulation.

8.5.4 GROUND ROCK TRANSFER SYSTEMS

Emissions from handling and storage of ground rock are very difficult to characterize owing to the fact that these systems vary greatly from plant to plant and no "typical" system can be defined. Moreover, a substantial portion of the potential emissions from handling and storage operations is fugitive emissions. Normal industrial practice is to control dust from the various sources by enclosures and air evacuation or pressure systems ducted to baghouses. Baghouses provide recovery of the rock dust which is subsequently returned to the rock inventory. Experience shows that no visible emissions occur from the enclosures when the process equipment is properly maintained. Consequently, emissions from ground rock transfer systems are manifested and monitored at the overall collection device (e.g., the baghouse). Because of wide variations in handling and storage facilities, a visible emission standard is the only standard appropriate for these facilities.

Three pneumatic systems employed in the transfer of ground phosphate rock were selected for emissions evaluation. Two of these systems transferred ground rock from a storage silo at a rock grinder to a storage silo at a wet-process phosphoric acid plant. The third system transferred ground rock from a rock grinder to a storage silo at a run-of-pile triple superphosphate plant. Emissions from the transfer systems were passed through baghouses which utilize air-to-cloth ratios of 4 to 1, 8 to 1, and 9 to 1. Visible emission measurements were made at the baghouse exhaust according to EPA Method 9.

The exhaust from the baghouses of each of the transfer systems was witnessed for visible emissions by two qualified observers during normal transfer operations for two hours at one system, and one hour at the others. The opacity level of the baghouse emissions was observed to be zero throughout the test periods. Based on these results, it is concluded that the visible emissions limit which reflects the level attainable by the best system of emissions reduction for phosphate rock handling and storage systems is zero opacity from any point in the transfer system.

8.6 VISIBLE EMISSION STANDARDS

The opacity level of visible emissions is an indication of the mass concentration of a particular pollutant. Various studies have shown that opacity varies directly with mass concentrations of particulate matter. The applicability and enforcement of opacity standards related to particulate matter have been established in several court cases for facilities subject to new source performance standards (NSPS) under Section 111 of the Clean Air Act.

Opacity standards help to assure that emission control systems are properly maintained and operated so as to comply with mass emission standards on a continuous basis. Opacity test methods are quicker, easier to apply, and less costly than concentration/mass tests for particulate matter. Since EPA considers opacity standards to be a necessary supplement to particulate mass emission standards, opacity levels are established as independent enforceable standards.

Where both opacity and concentration/mass standards are applicable to a given source, EPA establishes opacity standards for new source performance standards that are not more restrictive than the corresponding concentration/mass standard. The opacity standard is generally achievable if the source is in compliance with the concentration standard. In specific cases where it can be demonstrated that the opacity standard is being violated while the particulate standard is being met, provisions for individual review are included in 60.11(e) of 40 CFR 60.

8.6.1 Proposed Visible Emissions Standards

Visible emission data were obtained during the develppment of the proposed standards using EPA Reference Method 9 (6-minute average opacities based on the average of 24 observations (one every 15 seconds) during the 6-minute period). The tests were performed at facilities representing the best emission control technology currently employed by the industry. Appendix C contains data on visible emission observations performed at two dryers, two calciners, two grinders and three ground-rock handling systems. More than 100 man-hours of visible emission observations were performed (approximately 32 man-hours for dryers, 29 man-hours for calciners, 31 man-hours for grinders and 8 man-hours for ground-rock handling systems).

Phosphate Rock Dryers

Data on visible emissions from dryers were obtained for Facilities A and B. Facility A utilizes a Venturi Scrubber to control emissions and Facility B employs an electrostatic precipitator (ESP). Both facilities process Florida pebble rock, which is considered to produce the most adverse emission control problem.

Observations at Facility A included approximately eight hours of measurements for two separate dates. The observed opacity was zero throughout the test periods. The average particulate loading during the test was 0.015 gr/dscf or 0.039 lb/ton.

Observations at Facility B included approximately 6 hours of measurements on two separate dates. Opacity averages for six minute observations sets ranged from 0% to 7.7%. The average particulate concentration during the period of visual observations was 0.010 gr/dscf and the process weight emission rate was 0.025 lb/ton.

It may be noted that the facility exhibiting the highest opacity readings exhibited the lower values for particulate concentration in the stack gases. The difference between the opacity levels observed for the two types of control systems primarily reflects differences in diameters of discharge stacks rather than significant differences in control performance. ESPs typically require larger stacks due to higher volumes of flow required during operation. Setting separate opacity standards for the two control systems is not considered appropriate because ESPs are not expected to be used in meeting the proposed NSPS. Thus the proposed opacity standard is based on the performance of the scrubber-controlled facility and is set at zero percent opacity. Control systems reflecting best emissions control capability (the high energy scrubber or baghouse) and meeting the proposed emissions limit should experience no difficulty meeting the proposed opacity standard. Should any affected dryer facility be controlled with an ESP and comply with the particulate limit of 0.02 kg/Mg but not the opacity limits, a separate opacity limit may be established for that facility under 40 CFR 60.11(e). The provisions of 40 CFR 60.11(e) allow owners or operators of sources which exceed the opacity standard while concurrently achieving the performance emissions limit to request establishment of a specific opacity standard for that facility. Prior to establishing such a specific standard, the owner or operator must request opacity tests to be performed concurrently with the emissions performance tests.

Phosphate Rock Calciners

Particulate emissions were measured from fluid bed calciners at two phosphate rock plants (Facilities C and K). Each of the calciners are used to process western phosphate rock. Western rock may be considered to produce the more adverse conditions for emissions control because this rock is subject to less cleaning during beneficiation than other ore types. In addition, one of the two calciners processes a mix of both beneficiated and unbeneficiated rock, lending to a still more adverse control problem. Facility C utilizes a venturi scrubber for particulate control and Facility K employs an Entoleter Centrifield scrubber.

A total of 13.75 hours of visual emissions data was collected as a part of the testing procedures for these two facilities (on two separate dates for Facility C and on one date for Facility K). An opacity of zero percent was observed throughout the monitoring period at both facilities. During the sampling and analysis procedures at Facility C, the average measured particulate loading was 0.047 gr/dscf or 0.14 lb/ton. Particulate emissions data were not obtained simultaneously during the collection of visible emissions data at Facility K. However, the results of particulate sampling tests performed at Facility K in March, September and December of 1975 indicated particulate emissions of .082, .095 and .107 lb/ton of ore feed. Considering the fact that the results of these tests were relatively constant and made over a nine month period, it is reasonable to expect these levels to be representative of the levels that may have been measured in June 1976 when the observations of visual emissions were made.

Based on the test data, it is clear that the best emissions control equipment currently used for calciners (venturi scrubbers with a pressure drop of 12 inches at Facility C, and Entoleter Scrubber varying from 20 to 30 inches at Facility K) can maintain visible emission levels produced by the calcining process to a level no greater than zero percent opacity. The control technology which will be required by the proposed emissions standard represents a level of control exceeding that currently used on Facilities C and K. A visible emissions limit of zero percent opacity is recommended for phosphate rock calciners. Significant excursions of plume opacity above this level will be indicative of improper operation of the control equipment.

Phosphate Rock Grinders

Data on visible emissions from grinders were obtained at Facilities F and G. Close to 17 hours of data were recorded at these facilities (on two separate dates at each facility). The average opacity level recorded was zero throughout the measurement period. The average concentration of particulate emissions during the periods of observation were .002 and .002 gr/dscf of feed, for Facilities F and G, respectively. The respective mass weight emission rates were 0.0013 and 0.0009 lb/ton.

The use of baghouses as control devices on these two facilities represents demonstrated best technology, and test data shows that this level of control produces emissions exhibiting no greater than zero percent opacity. Therefore, EPA believes that the visible emission standard for phosphate rock grinding processes should be zero percent opacity.

Ground Rock Handling Systems

The visible emission standard for the ground-rock handling systems was discussed in Section 8.5. A visible emissions standard of zero percent opacity is proposed.

8.6.2 Measurement Difficulties for Steam Plumes

All visible observations of visible emissions from dryers and calciners were hampered by the steam content of the plume leaving the stack. For some industrial processes steam interference is of such a magnitude that the establishment of a visible emission standard would be impractical. For example, this was the reason given for not establishing a visible emission standard for hydrators used within the lime manufacturing industry[18].

However, the existence of steam in a plume is not, by itself, a sufficient reason to preclude the establishment of a visible emission standard. EPA Reference Method 9 instructs observers to make readings at a down-plume point where the steam has dissipated. The methodology of making visual measurements on steam plumes is an important part of the training of certified observers.

For the development of standards for dryers and calciners, over 60 man-hours of opacity readings were gathered by certified observers under a variety of conditions. EPA concludes that the observed values are valid, and therefore, the presence of interference from steam plumes does not preclude the establishment of a visible emission standard for those facilities.

8.7 MODIFICATION AND RECONSTRUCTION CONSIDERATIONS

The proposed standards would apply to specified systems (drying, calcining, grinding, and ground rock handling and storage systems) within the phosphate rock industry which are modified or constructed after the date of regulation proposal. Statutory and regulatory provisions defining "modification" and "reconstruction" are discussed in Chapter 5, and the general applicability of these provisions to the phosphate rock industry is described.

8.7.1 Modification

The information presented in Chapter 5 indicated that except for specified categories of changes, a modification is any physical or operational change to an existing facility which results in an increased emission rate of a pollutant to which a standard applies.

For the phosphate rock industry, it is unlikely that existing phosphate rock facilities will become "affected" facilities as a result of modification. The following series of physical or operational changes would be specifically exempted and would not be considered "modifications" regardless of their effects on emission rates:

1. Changes determined to be routine maintenance, repair, or replacement.

2. An increase in the production rate if that increase can be accomplished without a capital expenditure exceeding the existing facility's IRS annual asset guideline repair allowance of 6.5 percent per year.

3. An increase in the hours of operation.

4. Use of an alternative raw material, such as Florida land pebble, if the existing facility was designed to accommodate such material.

5. Use of an alternative fuel, such as switching from natural gas to fuel oil, if the existing facility was designed to accommodate the alternate fuel. If the facility was not so designed, the switch would be considered a modification unless it could be demonstrated that the new fuel did not result in an increase in emissions. However, pursuant to Section 113(d)(5) or Section 119 (as in effect before the date of enactment of the Clean Air Act Amendments of 1977) of the Act, conversion to coal required for energy considerations shall not be considered a modification.

6. The addition or use of any air pollution control system except when a system is removed or replaced with a system considered to be significantly less effective.

7. The relocation or change in ownership of an existing facility. However, the purchase and installation of a used piece of equipment at a stationary source to expand capacity would be considered new construction and, thus, subject to standards of performance.

8.7.2 Reconstruction

The replacement of facility components could be considered reconstruction if the fixed capital cost of replacement exceeds 50 percent of the cost to construct an entirely new facility.

One action which could be considered reconstruction for a dryer, calciner, grinder or ground rock transfer system would be the replacement and extensive refurbishing of power plant and drive mechanism, including motor, chains, belts, gears, couplings, reducers, clutches, bearings, etc. In such a case, the test involving the relationship between the fixed capital cost of the replacement versus the corresponding costs for complete reconstruction of the facility should be used to determine applicability of the reconstruction provision. The final determination will be made by the EPA Administrator based on information provided by the owner.

Replacement of facility components which are subjected to extreme heat (e.g., refractory linings) or attrition due to abrasion or impact (e.g., crushing surfaces, screening surfaces and conveyor belts) could be considered routine maintenance and may therefore be exempted by the reconstruction and modification provisions.

8.8 SELECTION OF MONITORING REQUIREMENTS

Under section 114(a) of the Clean Air Act, the Administrator may require the owner or operator of any stationary emission source to install, use, and maintain monitoring equipment or methods. EPA has exercised this authority in the standards of performance for several source categories by requiring the monitoring of pollutant emissions or parameters that are indicators of pollutant emissions. The requirements for continuous monitoring are necessary to determine if a control device is being properly operated and maintained. It also aids in determining when and if a performance test should be required. The costs of purchasing, installing, and operating the monitoring devices must be considered reasonable and affordable.

Opacity monitoring systems have been demonstrated as a reasonable and effective means of determining proper operation and maintenance of particulate emission control systems. Opacity standards are set at levels which ensure proper operation and maintenance of the control system, but which do not require use of a more efficient system. The opacity standards and continuous monitoring requirements do not impose additional significant requirements or costs over those required to comply with the numerical emissions limit standard. The opacity monitoring systems are also substantially less costly and more easily applied than periodic mass emissions tests for particulate matter.

When wet particulate collection devices (e.g., a Venturi scrubber) are employed to control emissions, entrained water droplets prevent the accurate measurement of opacity. In this case, continuous compliance through proper operation and maintenance of the control device would be determined by monitoring pertinent operating parameters of the control device. When a scrubber is used to control the emissions, the proposed standard would require monitoring the pressure drop across the scrubber and the scrubbing fluid supply pressure to the scrubber rather than opacity. Measurements which show significant deviation from levels maintained during the performance tests will indicate improper operation of the the control equipment.

8.8.1 Phosphate Rock Dryers and Calciners

Particulate emissions from phosphate rock dryers and calciners may be controlled with baghouses, electrostatic precipitators, or scrubbers. Each of these devices has been identified as an environmentally acceptable means of meeting the proposed emissions standard. The applicability and enforceability of continuous monitoring requirements for facilities controlling emissions with these control devices has been established for various industrial emmission sources regulated by NSPS. Accordingly, continuous monitoring of the opacity of the emissions from the calciners and dryers is recommended. However, when scrubbers are used to control emissions, monitoring of scrubber operating parameters (pressure drop and fluid supply pressure) would be recommended rather than opacity. Furthermore, if alternative controls are employed which would also preclude the use of a continuous monitoring system as specified by the standard, the operator may request establishment of alternative monitoring procedures or requirements under the provisions of 40 CFR 60.13(i).

As specified in Sections 60.7(b) and (c) of the regulations (Notification and Recordkeeping), the operator of any source subject to the proposed standards would be required to maintain records of the occurrence and duration of any periods of start-up, shutdown, or malfunction in the operation of an affected facility, any malfunction of the air pollution control equipment, or any periods during which a continuous monitoring system or monitoring device is not operating. All excess emissions must also be reported to EPA for each calendar quarter. Generally, excess emissions of opacity are defined as all six-minute average opacity values that exceed the proposed visible emission standard of zero percent opacity, except those occuring during start-up, shutdown, or malfunction of the facility or control device. Where scrubbers are used, excess emissions are indicated when parameter measurements are more than 10 percent below the average levels maintained during the most recent performance test in which compliance with the proposed standards was demonstrated.

Requirements for visible emissions monitoring equipment and procedures are outlined in Appendix B of 40 CFR 60. It should be noted that effluent gases from calciners and dryers may contain trace amounts of fluorides which react with moisture in the plume to form acids capable of etching glass materials. Glass lenses from opacity monitoring equipment should either be protected from fluoride containing gas streams, or replaced with a material not subject to etching.

8.8.2 Phosphate Rock Grinders and Ground Rock Handling Systems

Particulate emissions from grinders and ground rock handling systems are typically controlled with baghouses. Continuous monitoring of the opacity of emissions from these facilities will provide indication of suitable operation and maintenance of the baghouse controls. Should an operator choose to employ high energy scrubbers to meet the proposed NSPS, alternative monitoring requirements as discussed previously would be recommended. Record keeping and notification obligations associated with the monitoring requirements are the same as discussed in Section 8.8.1.

8.9 SELECTION OF PERFORMANCE TEST METHODS

The performance test method recommended for measurement of particulate emissions is EPA Reference Method 5, described in Appendix A of 40 CFR 60. Method 5 was utilized to determine particulate emissions rates for the source tests supporting the establishment of the proposed standard, and is typically applied as a performance test procedure for various stationary source categories for which NSPS have been promulgated. Under the proposed standards for phosphate rock plants, performance tests for particulate matter emissions would be required for air pollution control devices on all affected facilities.

A measurement of the mass rate of rock feed would also be required during a performance test, because the units of the proposed standards for dryers, calciners, and grinders are kilograms of particulate per megagram of phosphate rock feed. A measuring device such as a conveyer belt scales would be required to determine the mass rate of feed.

The test method recommended for measurement of visible emissions is EPA Reference Method 9, described in Appendix A of CFR 60. Method 9 was employed to acquire the visible emissions measurements used to support the proposed visible emissions standard for the four affected phosphate rock facilities, and is consistently applied to establish visible emissions standards for facilities subject to NSPS.

REFERENCES FOR CHAPTER 8

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[3] Stowasser, W. F. *op*. *cit*.

[4] Stowasser, W. F. *op*. *cit*.

[5] U. S. Department of Health, Education and Welfare. Air Quality Criteria for Particulate Matter. National Air Pollution Control Administration Publication Number AP-49. January 1969.

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[7] Letter from Mr. J. C. Barber, Tennessee Valley Authority, to Mr. Lee Beck, Environmental Protection Agency, dated November 18, 1975.

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[9] Letter from Mr. J. C. Barber, Tennessee Valley Authority, to Mr. Lee Beck, Environmental Protection Agency, dated November 18, 1975.

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[13] Betts, A. G. Recovery of Sulfur Dioxide (SO_2) from Gas Streams and Precipitation of Aluminum Fluorine Product. United States Patent Office Patent Number 3,697,248. October 10, 1972.

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16 Sparks, L.E., SR-52 Programmable Calculator Programs for Venturi Scrubbers and Electrostatic Precipitators, (EPA-600/7-78-026), March 1978.

17 Letter from J.L. Smith, Simplot Company, to Jack Farmer, Environmental Protection Agency, dated May 19, 1976, containing scrubber efficiency data for Venturi and Centrifield scrubber units.

18 Environmental Protection Agency, Standard Support and Environmental Impact Statement, Volume 1: Proposed Standards of Performance for Lime Manufacturing Plants, EPA-450/2-77-007a, April, 1977.

19 Engineering Science, Inc., EPA Report for Mobil Chemical Nichols, Florida. Prepared for Environmental Protection Agency, Office of Air Quality Programs and Standards, Emissions Measurement Branch, 01 January.

APPENDIX A. EVOLUTION OF THE SELECTION OF BEST SYSTEM OF EMISSION REDUCTION

A.1. BACKGROUND DEVELOPMENT

Federal emission control interest in the phosphate fertilizer industry, of which phosphate rock plants are a part, was first initiated by a 1970 U. S. Senate report from the Secretary of Health, Education and Welfare.[1] This report stated in part that the industry is a major source of fluorides which can cause damage to plants and livestock. Shortly thereafter, EPA began a study of the phosphate fertilizer industry to determine to what extent it contributes to air pollution. This study identified several sources of particulate and fluoride emissions and reported that substantial growth in the industry is likely.[2] As a result of the study, EPA developed standards of performance for sources of particulates and fluorides in the high growth fertilizer manufacturing processes. The standards were promulgated on August 6, 1975.[3] The study also identified several sources in the phosphate rock processing segment of the industry as having substantial potential for particulate emissions, which prompted this second phase of standards development for the industry.

In the course of the program to develop standards of performance, discussions were held to solicit information and data from practically all of the phosphate rock producers, two state agencies, EPA Region IV and two industry trade associations: The Fertilizer Institute and the Florida Phosphate Council. In addition, a telephone survey was undertaken to identify and locate well-controlled installations. EPA also enlisted several contractors to aid in the development of background information, cost data on air pollution control systems, and an analysis of the economic and environmental impacts of several levels of emissions control.

A.2. PLANT INSPECTIONS

From the information gathered, EPA engineers (and contractors in some cases) selected and visited 25 reportedly well-controlled plants to evaluate particulate emission control systems and to obtain information on process operations. Control systems were evaluated on the basis of:

- Design parameters.
- Emissions data from previous source tests.
- Visible emissions.
- Maintenance.
- Efficiency of the system in collecting the emissions and ducting them to the control devices.

In addition, process variables which affect the level of uncontrolled emissions, such as the type of process employed and the raw materials used, were noted to assure that the plants were representative of the industry.

A.3. DEVELOPMENT OF THE DATA BASE FOR THE STANDARD

Of the 25 plants visited, 12 were selected for further evaluation of their control systems by measuring their emissions. Results of most of these performance tests are summarized in Appendix C. These data, along with the cost and environmental impact of several levels of emission control, and recommended performance standards for phosphate rock plants, were presented to the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) on March 18, 1976.

EPA (with the aid of a contractor) completed the Background Information Document (including the Rationale Chapter), issue paper, preamble and proposed standard, and presented this documentation to the EPA Working Group on October 19, 1978. The proposed standard was similar to that recommended at the NAPCTAC meeting, although the format of the emissions limit was changed from a concentration limit to a mass emissions per unit feed limit. The Working Group also resolved to authorize an upgrade of the Background Information Document to improve the data base.

After an upgrading of the Background Information Document, and appropriate revision of the proposed standard, a documentation package consisting of the BID, preamble, proposed standard, and action memorandum was mailed on April 18, 1979 to the Steering Committee for review on a consent agenda.

Comments from the Steering Committee were received and incorporated as appropriate into the regulatory package. The revised package (the "AA Concurrent Package" was mailed in July 1979 to the Administrator.

REFERENCES FOR APPENDIX A

1. United States Senate. National Emission Standards Study. Senate Document No. 91-63. March 1970.
2. Chemical Construction Corporation. Engineering and Cost Study in the Phosphate Industry. Unpublished draft. EPA Contract No. CPA-70-156. August 1972.
3. Environmental Protection Agency. Federal Register. 40 CFR Part 60. pp. 33152-33166. Washington, D. C. U. S. Government. November 17, 1975.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system, cross-indexed with the October 21, 1974, Federal Register (39 FR 37419) containing the Agency guidelines concerning the preparation of Environmental Impact Statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the Federal Register guidelines.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT CONSIDERATIONS WITHIN THE DOCUMENT

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
1. Background and description of the proposed action.	
-Summary of proposed standards.	The standards are summarized in chapter 1, section 1.1.
-Statutory basis for the standard.	The statutory basis for the proposed standards (Section III of the Clean Air Act, as amended) is discussed in chapter 2.
-Purpose of the proposed standard.	Chapter 8, sections 8.1 and 8.2 provides a general discussion describing the overall purpose of the proposed standards and reasons why such standards are needed.
-Facility and process affected.	Descriptions of the facilities and processes affected by the proposed standards are given in chapter 3. Additional details concerning these facilities are provided in section 8.2.
-Relationship of actions and proposals by EPA, other agencies, government and private organizations to the proposed standards.	The interdependency of the phosphate rock and fertilizer production industries, and regulations concerning these industries are mentioned in section 8.1.
-Availability of Control Technology.	The various forms of emission control technology potentially available for use on phosphate rock processing facilities are discussed in chapter 4.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT CONSIDERATIONS WITHIN THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
-Existing regulations at state or local level.	A comparative discussion of the typical and most stringent state regulations which apply to the phosphate rock industry is presented in section 3.3. Additional information concerning regulations that apply to the industry in selected states is provided in section 6.2.1.1.
2. Alternatives to the proposed action.	
-Describe and objectively weigh reasonable alternatives to the proposed action, to the extent such alternatives are permitted by the law. . . For use as a reference point to which other actions can be compared, the analysis of alternatives should include the alternative of taking no action, or of postponing action. In addition, the analysis should include alternatives having different environmental impacts, including proposing standards, criteria, procedures, or actions of varying degrees of stringency. When appropriate, actions with similar environmental impacts but based on different technical approaches should be discussed. This analysis shall evaluate alternatives in such a manner that reviewers can judge their relative desirability.	The alternative control systems considered during the development of the proposed standard are discussed in chapter 4. Alternative plans of action, including the option of not establishing standards of performance, or postponing such standards are discussed in sections 6.3.1 and 6.3.3 respectively. Selection of the best system for emission reduction considering costs, is presented in section 8.3. Alternative formats to the proposed standard are presented in section 8.4. Included is the rationale used during the selection of the chosen format from other alternatives. Rationale for the selection of the particulate emission limits for the affected facilities is discussed in section 8.5. Rationale for the selection of a visible emission standard is provided in section 8.6.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT CONSIDERATIONS WITHIN THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
-The analysis should be sufficiently detailed to reveal the Agency's comparative evaluation of the beneficial and adverse environmental, health, social, and economic effects of the proposed action and each reasonable alternative.	The environmental and economic impacts of the proposed standards are summarized in section 1.2. Detailed information concerning the environmental impacts of the alternative control systems are presented in chapter 6. The discussion considers beneficial and adverse impacts on air, solid waste, energy, water, and radiation. A detailed analysis of the economic implications of the proposed standard is provided in sections 7.2 and 7.3.
-Where the authorizing legislation limits the Agency from taking certain factors into account in its decision making, the comparative evaluation should discuss all relevant factors, but clearly identify those factors which the authorizing legislation requires to be the basis of the decision making.	The factors which the authorizing legislation requires to be the basis of the decision making are discussed in chapter 2.
-In addition, the reasons why the proposed action is believed by the Agency to be the best course of action shall be explained.	The rationale for controlling particulate matter from phosphate rock plants through standards of performance is discussed in chapter 8, sections 8.1 and 8.2.
3. Environmental impact of the proposed action beyond the impacts resulting from compliance with current state requirements.	
A. Primary impact Primary impacts are those that can be attributed directly to the action, such as reduced levels of	The primary impacts on mass emissions and ambient air quality due to the alternative control systems are discussed in section 6.2.1. These impacts are also summarized in Table 1-2, Matrix of Environmental and Ecomonic

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT CONSIDERATIONS WITHIN THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
specific pollutants brought about by a new standard and the physical changes that occur in the various media with this reduction.	Impacts of the Proposed Standards presented in chapter 1.
B. Secondary impact Secondary impacts are indirect or induced impacts. For example, mandatory reduction of specific pollutants brought about by a new standard could result in the adoption of control technology that exacerbates another pollution problem and would be a secondary impact.	The secondary environmental impacts attributable to the alternative control systems are discussed in chapter 6. The impact of the energy requirements of alternative control systems is discussed in section 6.2.3. Secondary impacts on water is discussed in section 6.2.4. Secondary impacts associated with radiation is discussed in section 6.2.5.
4. Other considerations.	
A. Adverse impacts which cannot be avoided should the proposal be implemented. Describe the kinds and magnitudes of adverse impacts which cannot be reduced in severity to an acceptable level or which can be reduced to an acceptable level but not eliminated. These may include air or water pollution, damage to ecological systems, reduction in economic activities, threats to health, or undesirable land use patterns. Remedial, protective, and mitigative measures which will be taken as part of the proposed action shall be identified.	A summary of the potential adverse environmental and economic impacts associated with the proposed standards is discussed in chapter 1, section 1.2.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT CONSIDERATIONS WITHIN THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
B. Relationship between local short-term used of man's environment and the maintenance and enhancement of long-term productivity. Describe the extent to which the proposed action involves trade-offs between short-term environmental gains at the expense of long-term losses or vice versa and the extent to which the proposed action forecloses future options. Special attention shall be given to effects which pose long-term risks to health or safety. In addition, the timing of the proposed action shall be explained and justified.	The discussion of the use of man's environment is included in chapter 6. A discussion of the effects of emissions from phosphate rock plants is included in sections 8.1 and 8.2.
C. Irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. Describe the extent to which the proposed action curtails the diversity and range of beneficial uses of the environment. For example, irreversible damage can result if a standard is not sufficiently stringent.	Irreversible and irretrievable commitments of resources are discussed in section 6.2.6.

APPENDIX C. SUMMARY OF TEST DATA

A test program was undertaken by EPA to evaluate the best particulate control techniques available for controlling particulate emissions from phosphate rock dryers, calciners, grinders, and ground-rock handling systems. In addition, tests were performed to determine the amount of fluorides evolved from a calciner controlled by a venturi scrubber. This appendix describes the facilities tested and summarizes the results of particulate and fluoride emission tests and visible emission observations.

Two dryers, two calciners and four grinders were tested for particulate emissions using EPA Reference Method 5, and one calciner was tested for fluorides using EPA Reference Method 13. In addition, visible emission observations were performed at two dryers, one calciner, three grinders, and three ground-rock handling systems. These observations were performed using EPA Reference Method 9. Results of the front-half catches (probe and filter) from the particulate emission measurements conducted are graphed in Figures 1 and 3 for visual comparison and the complete results are presented in Tables C-1 through C-14. Results of visible emission observations are presented in Tables C-15 through C-35.

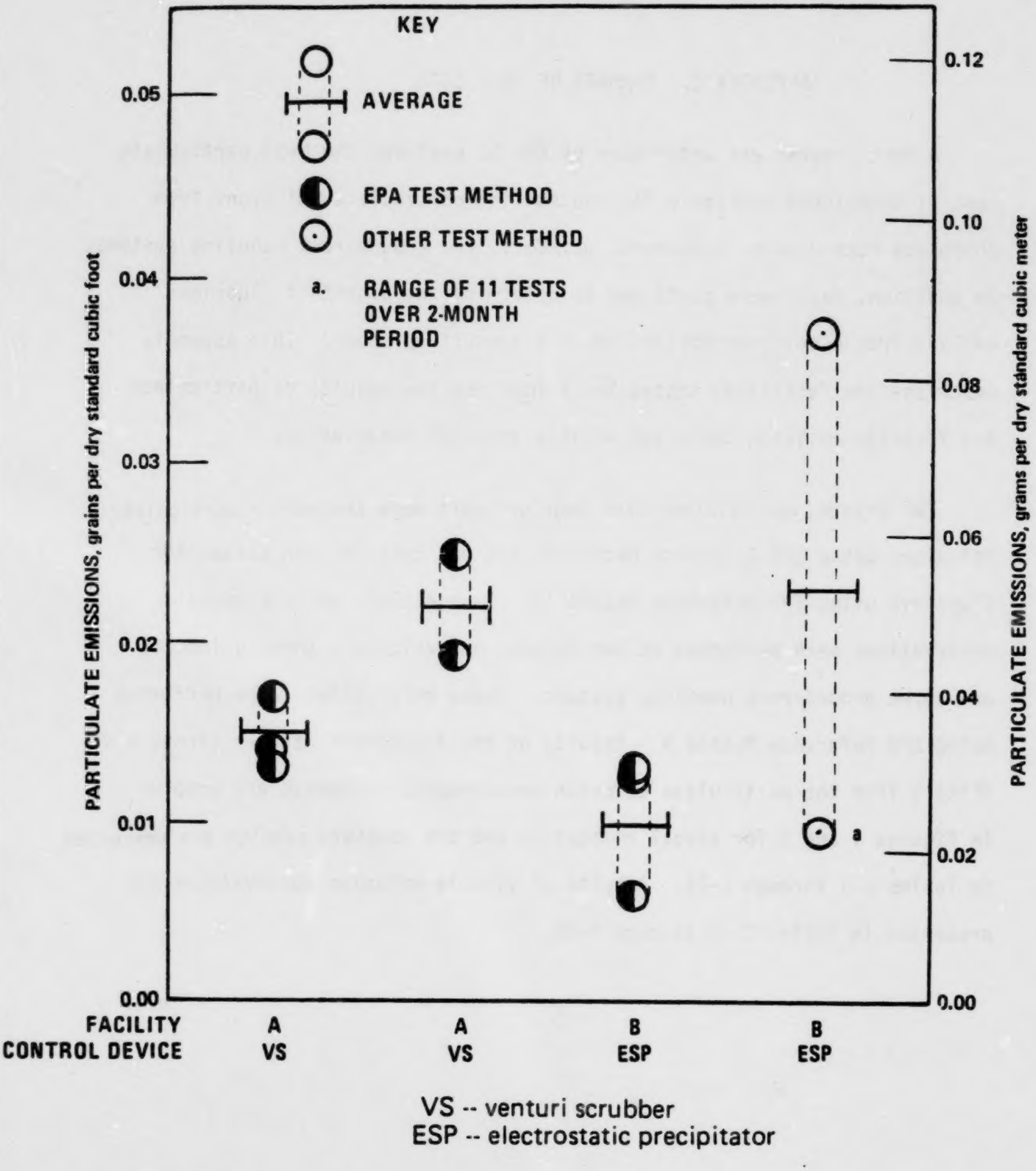

Figure C-1. Particulate emissions from phosphate rock dryers.

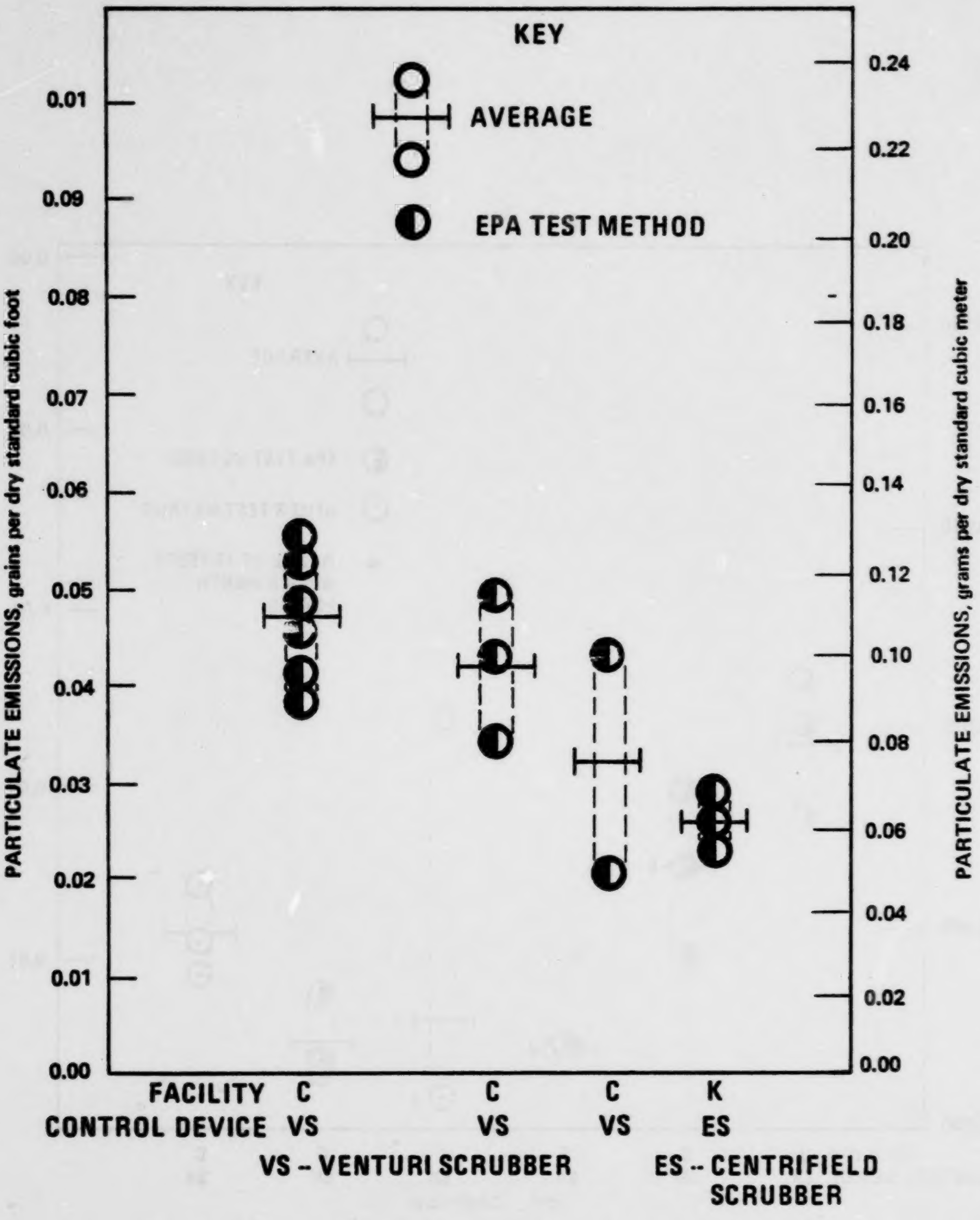

Figure C-2. Particulate emissions from phosphate rock calciners.

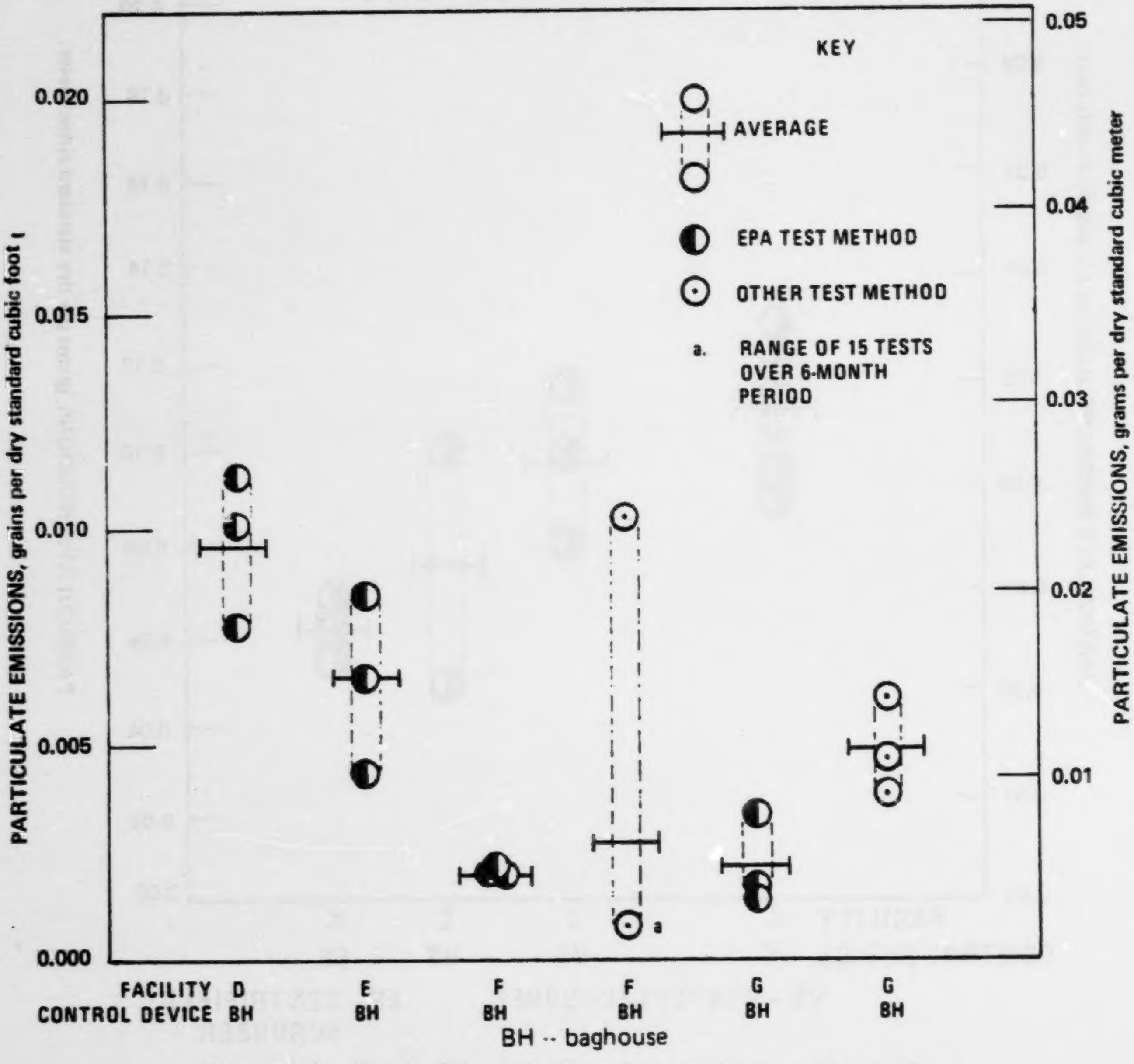

Figure C-3. Particulate emissions from phosphate rock grinders.

DESCRIPTION OF FACILITIES

A. Oil-fired (No. 6 fuel oil) rotary dryer designed to reduce the moisture in phosphate rock from between 10 and 15 percent to less than 3 percent. Its production rate varies from 220 TPH to 440 TPH, depending on the moisture content and the type of rock being processed. Florida land pebble was dried during each of the EPA tests and during the first test conducted by the operator. Flotation cell concentrates were being dried during the second operator test. Emissions from the dryer are cleaned by a Ducon venturi scrubber which has a pressure drop of 18 inches of water and uses 950 gal/min of recirculated water. EPA tests were conducted only while the process was operating normally. EPA and operator particulate measurements were performed using EPA Method 5. Visible emission measurements were made by EPA at the scrubber exhaust in accordance with EPA Method 9.

B. One oil-fired rotary dryer and one oil-fired fluid bed dryer operated in parallel. Nominal production rates are 330 TPH for the rotary dryer and 165 TPH for the fluid bed dryer; however, actual production rate is dependent on the amount of moisture and type of rock fed to the dryers. Both dryers were operated normally at full capacity and processed 100 percent Florida land pebble for each of the EPA tests. Emissions from both dryers are partially cleaned by two parallel impingement scrubbers (one for each dryer). Emissions from the scrubbers are combined and ducted to a two-stage wet electrostatic precipitator (ESP) which has a total collecting area of 50,600 square feet and a gas velocity of 1.53 feet per second. The cleaned gas exits the ESP from two vertical stacks. The ESP was reportedly designed for approximately twice the volume of gas currently being processed. EPA particulate measurements were performed using EPA Method 5. The operator conducted measurements using the State of Florida Department of Pollution Control Method. Visible emission observations were made at the ESP exhausts in accordance with EPA Method 9.

C. Fluid bed, oil-fired (No. 2 fuel oil) calciner used to remove moisture and organics from phosphate rock. Designed to calcine 70 TPH, but the operator has increased the calcining capacity to 80 TPH by drying a portion of the feed prior to calcination. Calciner emissions are cleaned by an ARCO venturi scrubber which has a pressure drop of 12 inches of water and uses about 600 gal/min recirculated water. Tests were conducted only while the process was operating normally. EPA and company particulate measurements were performed using EPA Method 5. The results of the tests by the Company are reported in Tables C-6 and C-7. Fluoride tests were performed using EPA Method 13, and visible emissions were recorded using EPA Method 9.

D. Kennedy Van Saun ball mill used to grind phosphate rock. Production throughput is nominally rated at 124 TPH, but is dependent on the degree of fineness to which the rock is ground. Emissions from the grinder are cleaned by a Mikro-Pulsaire baghouse. Tests were conducted only during normal process operation. Particulate measurements were performed using EPA Method 5. Visible emissions were not recorded.

E. Raymond roller mill used to grind dried phosphate rock. Production throughput is nominally rated at 35 TPH, but is dependent on the degree of fineness to which the rock is ground. During the first two tests, rock was ground to 65 percent through 200 mesh, and it was ground to 90 percent through 100 mesh (65 to 85 percent through 200 mesh), during the third test. Emissions from the grinder are cleaned by a baghouse. Tests were conducted only during periods when the process was operating normally. Particulate measurements were performed using EPA Method 5. Visible emission observations were made at the baghouse exhaust.

F. One roller mill and one ball mill operated in parallel. Production rates cannot be measured accurately, but experience shows that the roller mill normally operates at 27.5 TPH and ball mill at 50 TPH. The method used to determine if mills are operating at full capacity is by the amperage reading of the mill motors and fans. Mills were operated at full capacity during all EPA tests. Emissions from both grinders are combined and cleaned by a baghouse which has an air-to-cloth ratio of 4 to 1. Tests were conducted only while the process was operating normally. EPA particulate measurements were performed using EPA Method 5. Particulate measurements made by the operator were performed using Western Precipitation Method WP-50. The results are presented in Table C-12. Visible emission observations were made at the baghouse exhaust in accordance with EPA Method 9.

G. Harding ball mill used to grind calcined phosphate rock to 50 percent minus 200 mesh. Production throughput is nominally rated at 60 TPH. Emissions from the grinder are cleaned by a Mikropul, pulse-air cleaned baghouse with an air-to-cloth ratio of about 5 to 1. Tests were conducted only during periods when the process was operating normally. EPA and company particulate measurements were performed using EPA Method 5. Results of the Company tests are shown in Table C-14. Visible emission observations were made at the baghouse exhaust in accordance with EPA Method 9.

H. Pneumatic system for transferring ground phosphate rock from a storage silo at a phosphate rock grinder to a storage silo at a wet-process phosphoric acid plant. About 60 percent of the rock transferred is small enough to pass through a 200 mesh screen. The system was transferring about 60 tons of ground rock per hour, which is its normal operating rate. It has an exhaust gas flow rate of about 1700 dscfm. Emissions from the system pass first through a cyclone and then through a Mikro-Pulsaire baghouse which has an air-to-cloth ratio of about 4 to 1. Visible emission measurements were made at the baghouse exhaust in accordance with EPA Method 9.

I. Pneumatic system for transferring ground phosphate rock from a storage silo at a phosphate rock grinder to a storage silo at a wet-process phosphoric acid plant. About 60 percent of the rock transferred is small enough to pass through a 200 mesh screen. The system is designed to transfer about 47.5 tons of ground rock per hour, but can transfer a maximum of 87.5 tons per hour. It was operating at about 77.5 tons per hour during the EPA tests. Emissions from the transfer system exhaust through a cyclone to a Mikro-Pulsaire baghouse which has 36 bags, each of which are 96 inches long by 4.5 inches in diameter. The exhaust gas flow rate is about 2,500 dscfm and the air-to-cloth ratio is about 8 to 1. Visible emission measurements were made at the baghouse exhaust in accordance with EPA Method 9.

J. Pneumatic system for transferring ground phosphate rock from a phosphate rock grinder to a storage silo at a run-of-pile triple superphosphate plant. About 70 percent of the rock transferred is small enough to pass through a 200 mesh screen. The system was transferring about 15 tons of ground rock per hour, which is its normal operating rate. It has an exhaust gas flow rate of about 2000 dscfm. Emissions from the system pass through a cyclone to a baghouse which has 25 bags, each of which are 96 inches long by 4.5 inches in diameter, yielding an air-to-cloth ratio of about 9 to 1. Visible emission measurements were made at the baghouse exhaust in accordance with EPA Method 9.

K. Fluid bed, natural gas-fired calciner used to remove moisture and organics from phosphate rock. Designed to calcine 46 tph, but operator has difficulty maintaining the design production rate because of lack of surge capacity between calciner and grinder. Calciner emissions are cleaned by an Entoleter Centrifield scrubber which operates in a range of 20 to 30 inches of water pressure drop. Particulate measurements were conducted by the operator using EPA Method 5 while the calciner was operating normally. Visible emissions were recorded by EPA using EPA Method 9. Visible emission measurements were not recorded simultaneously with the Method 5 tests.

TABLE C-1

FACILITY A

Summary of Results of Tests of a Dryer

Run Number	1	2	3	Average
Date	3/18/75	3/18/75	3/19/75	-
Test Time - Minutes	108	108	108	108
Production Rate - TPH	250	235	240	242
Stack Effluent (From a Scrubber)				
Flow rate - ACFM	116,786	115,967	116,437	116,397
Flow rate - DSCFM	73,289	74,553	73,782	73,875
Temperature - °F	153	152	153	153
Water vapor - Vol. %	27.4	25.7	26.6	26.6
Visible Emissions at Collector Discharge - % Opacity	See Tables C-15 through C-17			
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.014	0.017	0.013	0.015
gr/ACF	0.009	0.011	0.008	0.009
lb/hr	9.07	11.14	8.04	9.42
lb/ton	0.036	0.047	0.034	0.039
Total catch				
gr/DSCF	0.058	0.042	0.051	0.051
gr/ACF	0.037	0.028	0.032	0.032
lb/hr	36.57	27.46	32.44	32.16
lb/ton	0.146	0.117	0.135	0.133

TABLE C-2

FACILITY A

Summary of Results of Tests of a Dryer

Run Number	1	2	Average
Date	9/4/74	9/8/74	-
Test Time - Minutes	NR	NR	-
Production Rate - TPH	360	360	360
Stack Effluent (From a Scrubber)			
Flow rate - ACFM	114,000	104,000	109,000
Flow rate - DSCFM	68,000	62,000	65,000
Temperature - °F	160	159	160
Water vapor - Vol. %	25.6	23.9	24.8
Visible Emissions at Collector Discharge - % Opacity		NR	
Particulate Emissions			
Probe and filter catch			
gr/DSCF [a]	0.025	0.018	0.022
gr/ACF [a]	0.015	0.011	0.013
lb/hr	14.7	10.0	12.3
lb/ton	0.041	0.036	0.038
Total catch			
gr/DSCF [a]	0.046	0.040	0.043
gr/ACF [a]	0.027	0.024	0.026
lb/hr	26.7	21.5	24.1
lb/ton	0.074	0.060	0.067

[a] Calculated

NR - Not Reported

TABLE C-3

FACILITY B

Summary of Results of Tests of a Dryer

Run Number	1	2	3	Average
Date	3/20/75	3/20/75	3/24/75	-
Test Time - Minutes	108	108	108	108
Production Rate - TPH	394	394	379	389
Stack Effluent (From an ESP)				
Flow rate - ACFM	134,463	133,566	129,084	132,371
Flow rate - DSCFM	113,144	110,758	111,918	111,940
Temperature - °F	112	115	104	110
Water vapor - Vol. %	9.2	10.0	7.46	8.9
Visible Emissions at Collector Discharge - % Opacity	See Tables C-18 through C-20			
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.012	0.013	0.005	0.010
gr/ACF	0.010	0.010	0.005	0.008
lb/hr	11.91	12.08	5.23	9.74
lb/ton	0.030	0.031	0.014	0.025
Total catch				
gr/DSCF	0.015	0.016	0.009	0.013
gr/ACF	0.013	0.014	0.008	0.011
lb/hr	14.66	15.06	8.80	12.84
lb/ton	0.037	0.038	0.023	0.033

TABLE C-4

FACILITY B
Summary of Results of Tests of a Dryer

Date	6/10/74 - 8/14/74
Test Time - Minutes	NR
Production Rate - TPH	423
Stack Effluent (From an ESP)	
Flow rate - ACFM	124,373
Flow rate - DSCFM[b]	115,348
Temperature - °F	NR
Water vapor - Vol. %	NR
Visible Emissions at Collector Discharge - % Opacity	NR
Particulate Emissions	
Probe and filter catch	
gr/DSCF	NR
gr/ACF	NR
lb/hr	NR
lb/ton	NR
Total catch	
gr/DSCF[c]	0.023
gr/ACF[c]	0.021
lb/hr	22.8
lb/ton[c]	0.054

[a] Average of 11 tests, 9 of which were performed while both dryers were fired with natural gas.

[b] Calculated; assuming a stack gas temperature of 110°F.

[c] Calculated.

NR - Not Reported

TABLE C-5

FACILITY C

Summary of Results
of Tests of a Calciner

Run Number	1	2	3	4	5	6	Average
Date	4/8/75	4/8/75	4/9/75	4/9/75	4/10/75	4/10/75	-
Test Time - Minutes	120	120	120	120	120	120	120
Production Rate - TPH	80	80	80	80	80	80	80
Stack Effluent (From a Scrubber)							
Flow rate - ACFM	47,197	50,160	51,456	54,719	50,324	49,262	50,520
Flow rate - DSCFM	25,319	27,764	28,407	28,005	27,525	26,338	27,226
Temperature - °F	141.5	143.5	145.8	158.5	146.0	144.6	146.7
Water vapor - Vol. %	25.1	22.6	22.5	26.7	23.1	25.0	24.2
Visible Emissions at Collector Discharge - % Opacity	0	0	0	0	0	0	0
Particulate Emissions							
Probe and filter catch							
gr/DSCF	0.038	0.055	0.048	0.046	0.041	0.053	0.047
gr/ACF	0.020	0.030	0.027	0.023	0.023	0.028	0.025
lb/hr	8.18	13.10	11.8	10.98	9.75	11.99	9.20
lb/ton	0.10	0.16	0.15	0.14	0.12	0.15	0.14
Total catch							
gr/DSCF	0.040	0.057	0.051	0.057	0.044	0.067	0.053
gr/ACF	0.021	0.031	0.028	0.029	0.024	0.035	0.028
lb/hr	8.62	13.46	12.49	13.68	10.44	15.03	12.29
lb/ton	0.11	0.17	0.16	0.17	0.13	0.19	0.15

NR - Not Recorded

TABLE C-6

FACILITY C

Summary of Results
of Tests of a Calciner

Run Number	1	2	3	Average
Date	10/2/73	10/3/73	10/3/73	-
Test Time - Minutes	98	98	98	98
Production Rate - TPH	51.7	35.9	35.9	41.2
Stack Effluent (From a Scrubber)				
Flow rate - ACFM	46,850	38,391	41,069	42,103
Flow rate - DSCFM	29,558	25,540	26,885	27,328
Temperature - °F	131	124	126	127
Water vapor - Vol. %	12.38	9.51	10.81	10.90
Visible Emissions at Collector Discharge - % Opacity	NR	NR	NR	-
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.034	0.043	0.049	0.042
gr/ACF	0.021	0.028	0.032	0.027
lb/hr	8.54	9.32	11.30	9.46
lb/ton	0.17	0.23	0.31	0.24
Total catch				
gr/DSCF	NR	NR	NR	-
gr/ACF	NR	NR	NR	-
lb/hr	NR	NR	NR	-
lb/ton	NR	NR	NR	-

NR - Not Reported

TABLE C-7

FACILITY C

Summary of Results of Tests of a Calciner

Run Number	1	2	Average[a]
Date	8/20/74	8/20/74	-
Test Time - Minutes	120	120	120
Production Rate - TPH	64.8	64.8	64.8
Stack Effluent (From a Scrubber)			
Flow rate - ACFM	48,324	48,578	48,451
Flow rate - DSCFM	32,841	32,671	32,756
Temperature - °F	131	133	132
Water vapor - Vol. %	6.03	6.70	6.37
Visible Emissions at Collector Discharge - % Opacity	NR	NR	-
Particulate Emissions			
Probe and filter catch			
gr/DSCF	0.043	0.020	0.032
gr/ACF	0.029	0.013	0.021
lb/hr	12.03	5.58	8.80
lb/ton	0.186	0.086	0.136
Total catch			
gr/DSCF	NR	NR	-
gr/ACF	NR	NR	-
lb/hr	NR	NR	-
lb/ton	NR	NR	-

[a] Two of three tests were averaged. The third test was invalidated by sample contamination.

NR - Not Reported

TABLE C-7a
FACILITY K
Summary of Results of Tests of a Calciner

Run Number	1	2	3	Average
Date	3/9/75	9/2/75	12/17/75	
Test Time - Minutes	NR	NR	NR	
Production Rate - TPH	27	25	25	25.7
Stack Effluent				
Flow rate - ACFM	NR	NR	NR	
Flow rate - DSCFM	11,100	10,900	10,900	10,967
Temperature - °F	NR	NR	NR	
Water vapor - Vol. %	NR	NR	NR	
Visible Emission at Collector Discharge - % Opacity	NR	NR	NR	
Particulate Emissions				
Probe and filter catch				
gr/DSCF(1)	0.023	0.025	0.028	0.025
gr/ACF	NR	NR	NR	
lb/hr	2.21	2.37	2.67	7.26
lb/ton	0.082	0.095	0.107	0.094
Total catch				
gr/DSCF	NR	NR	NR	
gr/ACF	NR	NR	NR	
lb/hr	NR	NR	NR	
lb/ton	NR	NR	NR	

(1) Calculated from information submitted by operator

NR - Not Reported

TABLE C-8

FACILITY C

Summary of Results of Tests of a Calciner

Run Number	1	2	3	4	5	6	Average
Date	4/4/75	4/5/75	4/8/75	4/8/75	4/9/75	4/10/75	-
Test Time - Minutes	120	120	120	120	120	120	120
Production Rate - TPH	80	80	80	80	80	80	80
Stack Effluent (From a Scrubber)							
Flow rate - ACFM	53,213	50,116	47,101	49,251	55,430	49,563	50,779
Flow rate - DSCFM	27,965	27,752	26,267	26,803	28,275	26,663	27,288
Temperature - °F	146.3	145.0	143.3	144.4	152.5	143.5	145.8
Water vapor - Vol. %	26.1	22.3	21.9	23.8	27.6	24.6	24.5
Visible Emissions at Collector Discharge - % Opacity	0	0	0	0	0	0	0
Fluoride Emissions							
Total catch							
gr/DSCF	0.00020	0.00038	0.00092	0.00046	0.00035	0.00104	0.00056
gr/ACF	0.00010	0.00021	0.00051	0.00025	0.00018	0.00056	0.00030
lb/hr	0.05	0.09	0.21	0.11	0.08	0.24	0.13
lb/ton	0.0006	0.0011	0.0026	0.0014	0.0010	0.0030	0.0016

TABLE C-9

FACILITY D

Summary of Results
of Tests of a Grinder

Run Number	1	2	3	Average
Date	1/11/73	1/11/73	1/12/73	-
Test Time - Minutes	128	128	128	128
Production Rate - TPH	121	131	120	124
Stack Effluent (From a Baghouse)				
Flow rate - ACFM	15,200	14,700	14,900	14,900
Flow rate - DSCFM	13,200	12,800	13,000	13,600
Temperature - °F	115	115	118	116
Water vapor - Vol. %	5.80	6.10	5.30	5.70
Visible Emissions at Collector Discharge - % Opacity	NR	NR	NR	NR
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.0102	0.0115	0.0078	0.0098
gr/ACF	0.0089	0.0100	0.0068	0.0072
lb/hr	1.154	1.270	0.869	1.098
lb/ton	0.0095	0.0097	0.0072	0.0088
Total catch				
gr/DSCF	0.0132	0.0155	0.0100	0.0129
gr/ACF	0.0114	0.0134	0.0087	0.0095
lb/hr	1.49	1.70	1.11	1.43
lb/ton	0.0123	0.0130	0.0093	0.0012

NR - Not Recorded

TABLE C-10

FACILITY E

Summary of Results
of Tests of a Grinder

Run Number	1	2	3	Average
Date	2/16/73	2/16/73	2/16/73	-
Test Time - Minutes	120	120	120	120
Production Rate - TPH	36.0	36.0	33.0	35.0
Stack Effluent (From a Baghouse)				
Flow rate - ACFM	3,295	3,256	3,386	3,312
Flow rate - DSCFM	2,720	2,654	2,751	2,708
Temperature - °F	161	161	161	161
Water vapor - Vol. %	5.32	6.05	6.53	5.97
Visible Emissions at Collector Discharge - % Opacity	NR	NR	NR	NR
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.0085	0.0066	0.0044	0.0065
gr/ACF	0.0070	0.0054	0.0035	0.0053
lb/hr	0.198	0.149	0.102	0.150
lb/ton	0.0055	0.0041	0.0031	0.0042
Total catch				
gr/DSCF	0.0149	0.0178	0.0080	0.0136
gr/ACF	0.0122	0.0146	0.0065	0.0111
lb/hr	0.347	0.406	0.188	0.314
lb/ton	0.0096	0.0113	0.0057	0.0089

NR - Not Reported

TABLE C-11

FACILITY F

Summary of Results of Tests of a Grinder

Run Number	1	2	3	Average
Date	3/25/75	3/25/75	3/26/75	-
Test Time - Minutes	120	120	120	120
Production Rate - TPH [a]	77.5	77.5	77.5	77.5
Stack Effluent (From a Baghouse)				
Flow rate - ACFM	8,385	8,582	7,897	8,288
Flow rate - DSCFM	6,676	6,809	6,449	6,645
Temperature - °F	146	155	139	147
Water vapor - Vol. %	9.47	8.47	8.79	8.91
Visible Emissions at Collector Discharge - % Opacity	0	0	0	0
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.002	0.002	0.002	0.002
gr/ACF	0.002	0.001	0.001	0.001
lb/hr	0.117	0.099	0.093	0.103
lb/ton	0.0015	0.0013	0.0012	0.0013
Total catch				
gr/DSCF	0.003	0.003	0.002	0.003
gr/ACF	0.002	0.002	0.002	0.002
lb/hr	0.159	0.159	0.116	0.145
lb/ton	0.0021	0.0021	0.0015	0.0019

[a] Production rate cannot be measured. 77.5 TPH is the normal production rate when both mills are running at full capacity. Emission rate in lb/ton was calculated using the normal production rate.

TABLE C-12

FACILITY F

Summary of Results of Tests of a Grinder

Run Number	Average[a]
Date	1/3/74 - 6/27/74
Test Time - Minutes	NR
Production Rate - TPH	NR
Stack Effluent (From a Baghouse)	
Flow rate - ACFM	NR
Flow rate - DSCFM	5,133
Temperature - °F	NR
Water vapor - Vol. %	NR
Visible Emissions at Collector Discharge - % Opacity	NR
Particulate Emissions	
Probe and filter catch	
gr/DSCF	NR
gr/ACF	NR
lb/hr	NR
lb/ton	NR
Total catch	
gr/DSCF[b]	0.0028
gr/ACF	NR
lb/hr	0.12
lb/ton	NR

[a] Average of 15 tests.

[b] Calculated.

NR - Not Reported

TABLE C-13

FACILITY G

Summary of Results of Tests of a Grinder

Run Number	1	2	3	Average
Date	4/5/75	4/7/75	4/7/75	-
Test Time - Minutes	200	200	200	200
Production Rate - TPH	81.4	81.0	80.8	81.1
Stack Effluent (From a Baghouse)				
Flow rate - ACFM	6,713	6,830	6,446	6,663
Flow rate - DSCFM	4,194	4,286	3,983	4,124
Temperature - ^{o}F	233	231	241	235
Water vapor - Vol. %	0.0	0.0	0.0	0.0
Visible Emissions at Collector Discharge - % Opacity	0	0	0	0
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.0014	0.0034	0.0016	0.0021
gr/ACF	0.0009	0.0021	0.0011	0.0014
lb/hr	0.05	0.12	0.06	0.08
lb/ton	0.0006	0.0015	0.0007	0.0009
Total catch				
gr/DSCF	0.0015	0.0038	0.0039	0.0031
gr/ACF	0.0009	0.0024	0.0024	0.0019
lb/hr	0.05	0.14	0.13	0.12
lb/ton	0.0006	0.0017	0.0016	0.0013

TABLE C-14

FACILITY G

Summary of Results
of Tests of a Grinder

Run Number	1	2	3	Average
Date	10/3/73	10/3/73	10/3/73	-
Test Time - Minutes	120	120	120	120
Production Rate - TPH	52	52	52	52
Stack Effluent (From a Baghouse)				
Flow rate - ACFM	8,242	8,423	8,058	8,241
Flow rate - DSCFM	5,635	5,661	5,408	5,568
Temperature - °F	159	177	177	171
Water vapor - Vol. %	0.84	0.00	0.00	0.28
Visible Emissions at Collector Discharge - % Opacity	NR	NR	NR	-
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.0047	0.0061	0.0038	0.0049
gr/ACF	0.0032	0.0041	0.0025	0.0033
lb/hr	0.23	0.30	0.18	0.24
lb/ton	0.0044	0.0057	0.0034	0.0045
Total catch				
gr/DSCF	NR	NR	NR	-
gr/ACF	NR	NR	NR	-
lb/hr	NR	NR	NR	-
lb/ton	NR	NR	NR	-

NR - Not Reported

Table C-15
FACILITY A
SUMMARY OF VISIBLE EMISSIONS

Date: March 18, 1975

Type of Plant: Phosphate Rock Dryer

Type of Discharge: Stack from scrubber

Distance from Observer to Discharge Point: 2000 feet

Location of Discharge: Top of stack

Height of Point of Discharge: 96 feet

Height of Observation Point: Ground level

Description of Background: Gray sky

Direction of Observer from Discharge Point: Northwest

Description of Sky: Overcast

Wind Direction: East

Wind Velocity: 7

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: Yes

Duration of Observation: 3 hours, 9 minutes

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	9:00	9:06	0	21			0
2	*		0	22			0
3			0	23			0
4			0	24			0
5			0	25			0
6			0	26			0
7			0	27			0
8			0	28			0
9			0	29			0
10			0	30			0
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

*Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-15, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

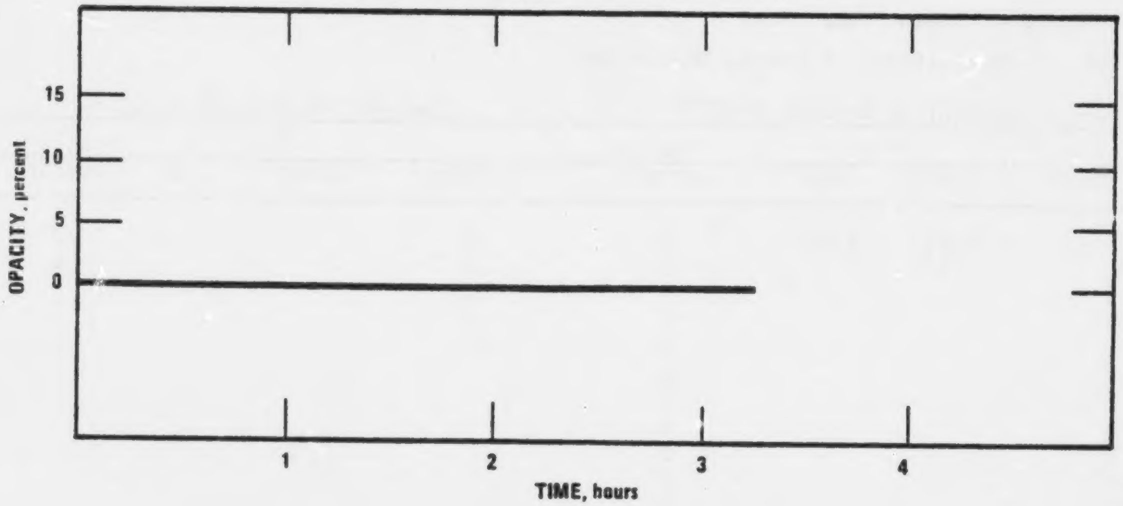

Table C-16

FACILITY A

SUMMARY OF VISIBLE EMISSIONS

Date: March 18, 1975

Type of Plant: Phosphate rock dryer

Type of Discharge: Stack from scrubber

Location of Discharge: Top of stack

Height of Point of Discharge: 96 feet

Description of Background: Cloudy sky

Description of Sky: Cloudy

Wind Direction: South-West

Color of Plume: White

Interference of Steam Plume: Yes

Duration of Observation: 2 hours, 29 minutes

Distance from Observer to Discharge Point: 1000

Height of Observation Point: Ground level

Direction of Observer from Discharge Point: North-West

Wind Velocity: 15 mi/hr

Detached Plume: No

SUMMARY OF AVERAGE OPACITY

	Time		Opacity
Set Number	Start	End	Average
1	4:22	4:28	0
2	*		0
3			0
4			0
5			0
6			0
7			0
8			0
9			0
10			0
11			0
12			0
13			0
14			0
15			0
16			0
17			0
18			0
19			0
20			0

SUMMARY OF AVERAGE OPACITY

	Time		Opacity
Set Number	Start	End	Average
21			0
22			0
23			0
24			0
25			0

* Subsequent sets were each of 6-minute durations, and there were no time lapses between sets.

Table C-16, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

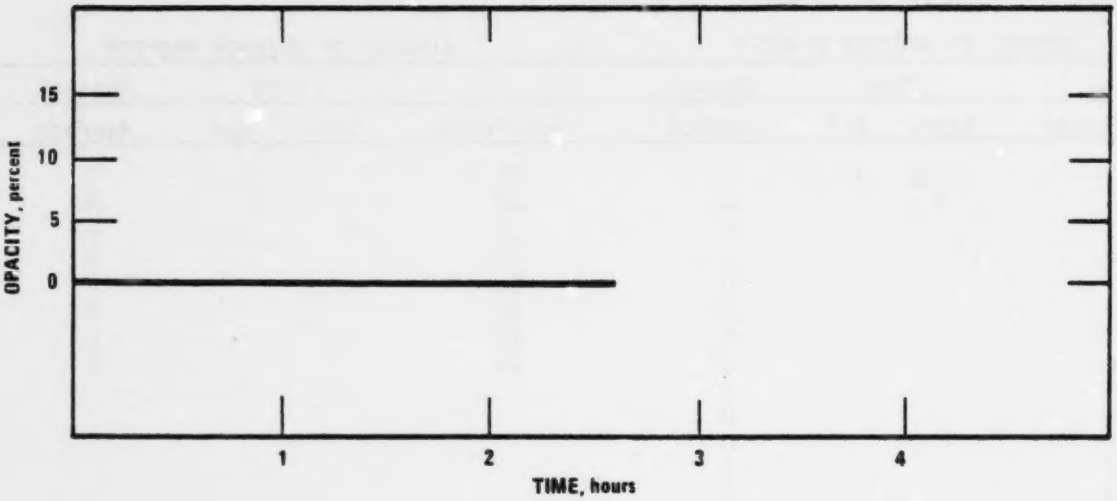

Table C-17
FACILITY A
SUMMARY OF VISIBLE EMISSIONS

Date: March 19, 1975

Type of Plant: Phosphate rock dryer

Type of Discharge: Stack from scrubber

Distance from Observer to Discharge Point: 300 feet

Location of Discharge: Top of stack

Height of Point of Discharge: 96 feet

Height of Observation Point: Ground level

Description of Background: Blue sky

Direction of Observer from Discharge Point: South

Description of Sky: Clear

Wind Direction: West Northwest

Wind Velocity: 15-30

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: Yes

Duration of Observation: 2 hours, 51 minutes

SUMMARY OF AVERAGE OPACITY

	Time		Opacity
Set Number	Start	End	Average
1	11:30	11:36	0
2	*		0
3			0
4			0
5			0
6			0
7			0
8			0
9			0
10			0
11			0
12			0
13			0
14			0
15			0
16			0
17			0
18			0
19			0
20			0
21			0
22			0
23			0
24			0
25			0
26			0
27			0
28			0

* Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-17, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

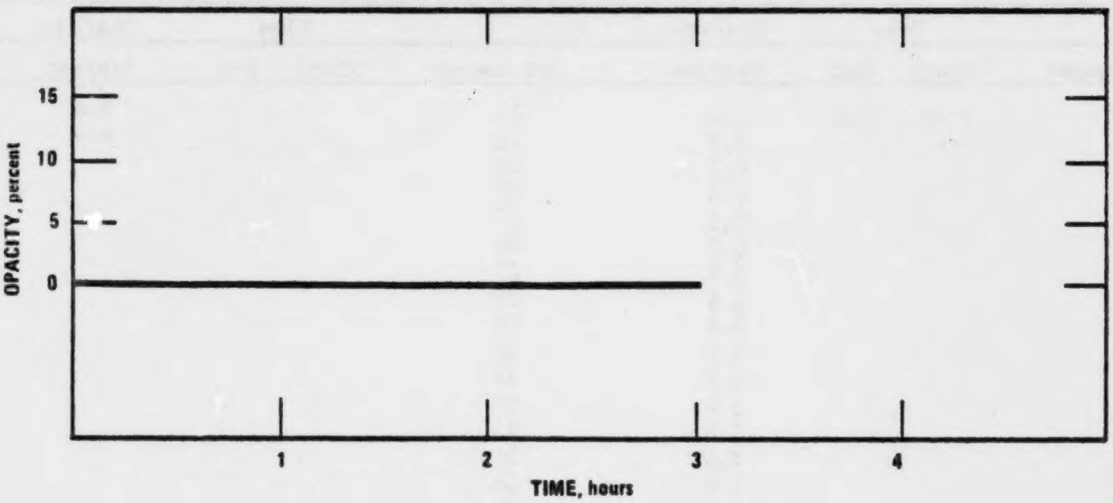

Table C-18

FACILITY B

SUMMARY OF VISIBLE EMISSIONS*

Date: March 20, 1975

Type of Plant: Phosphate rock dryer

Type of Discharge: Stack from electrostatic precipitator

Location of Discharge: Stack

Height of Point of Discharge: ≈90 feet

Description of Background: Blue sky

Description of Sky: Clear

Wind Direction: West

Color of Plume: White

Interference of Steam Plume: Yes

Duration of Observation: 2 hours, 15 minutes

Distance from Observer to Discharge Point: 150 feet

Height of Observation Point: Ground level

Direction of Observer from Discharge Point: South Southeast

Wind Velocity: 8

Detached Plume: No

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Average
1	2:00	2:06	5.0
2	**		7.7
3			6.7
4			5.0
5			5.8
6			6.7
7			7.1
8			5.0
9			5.4
10			5.6
11			5.6
12			5.0
13			5.0
14			4.6
15			5.0
16			5.0
17			5.0
18			5.0
19			4.6
20			5.0

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Average
21			5.6
22			6.9
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			

*Four observers made simultaneous readings (two observers for each of two stacks). The greatest of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-18, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

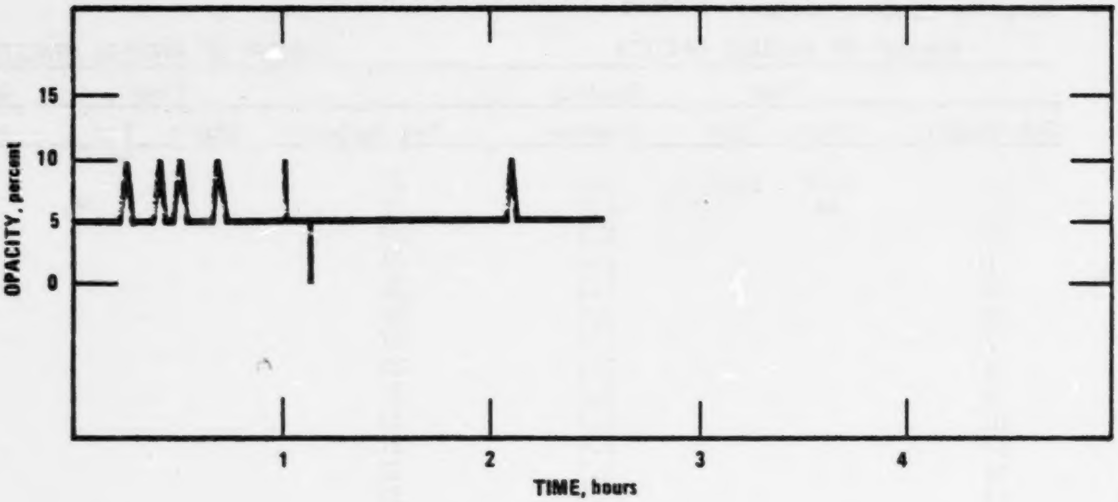

Table C-19
FACILITY B
SUMMARY OF VISIBLE EMISSIONS*

Date: March 20, 1975

Type of Plant: Phosphate rock dryer

Type of Discharge: Stack from electrostatic precipitator

Location of Discharge: Top of stack

Height of Point of Discharge: ≈ 90 feet

Description of Background: Clear blue sky

Description of Sky: Clear

Wind Direction: Northeast

Color of Plume: White

Interference of Steam Plume: Yes

Duration of Observation: 2 hours

Distance from Observer to Discharge Point: 150 feet

Height of Observation Point: Ground level

Direction of Observer from Discharge Point: South Southeast

Wind Velocity: 10

Detached Plume: Yes

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	5:17	5:23	3.8	21			0
2	**		4.6	22			0
3			2.3	23			
4			2.9	24			
5			1.0	25			
6			3.1	26			
7			1.7	27			
8			0.8	28			
9			0.6	29			
10			0.8	30			
11			0.4	31			
12			2.1	32			
13			2.9	33			
14			1.2	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

*Four observers made simultaneous readings (two observers for each of two stacks). The greatest of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-19, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

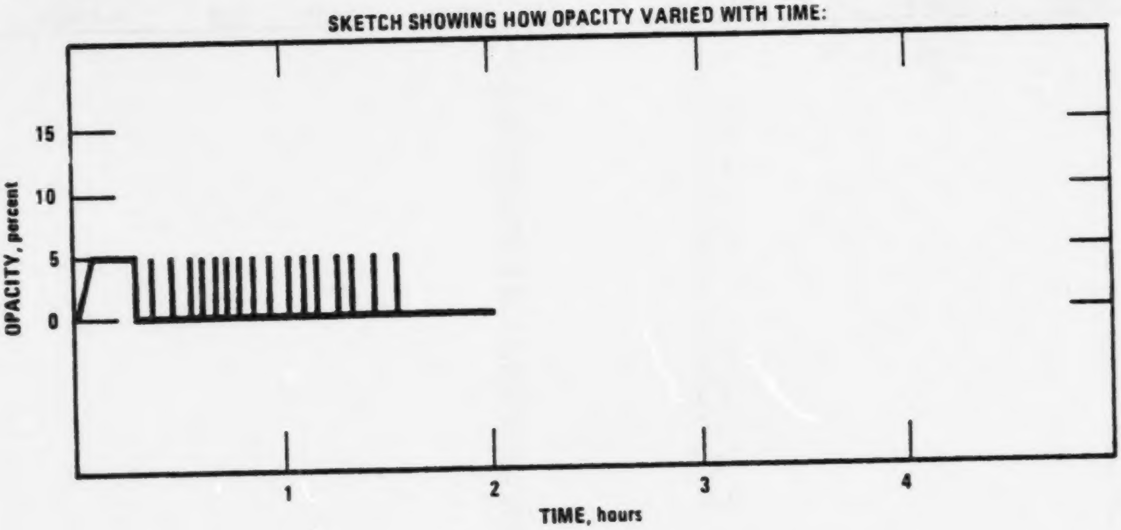

Table C-20

FACILITY B

SUMMARY OF VISIBLE EMISSIONS *

Date: March 24, 1975

Type of Plant: Phosphate rock dryer

Type of Discharge: Stack from electrostatic precipitator

Distance from Observer to Discharge Point: 120 feet

Location of Discharge: Stack

Height of Point of Discharge: 90 feet

Height of Observation Point: Ground level

Description of Background: Cloudy sky

Direction of Observer from Discharge Point: Soutneast

Description of Sky: Partly cloudy

Wind Direction: Southwest

Wind Velocity: 25

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: Yes

Duration of Observation: 103 minutes, 15 seconds

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	1:05	1:11	4.8	21			
2	**		4.8	22			
3			4.0	23			
4			4.6	24			
5			4.4	25			
6			4.7	26			
7			5.2	27			
8			4.8	28			
9			4.6	29			
10			4.8	30			
11			2.9	31			
12			4.0	32			
13			3.8	33			
14			3.9	34			
15			4.0	35			
16			4.2	36			
17			0	37			
18			4.0	38			
19				39			
20				40			

*Four observers made simultaneous readings (two observers for each of two stacks). The greatest of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-20, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

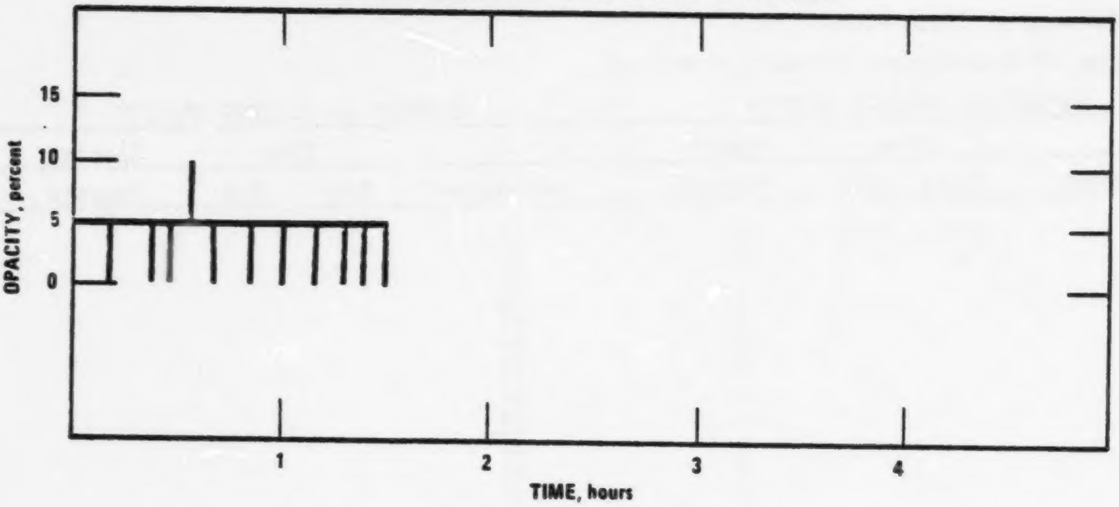

Table C-21

FACILITY C

SUMMARY OF VISIBLE EMISSIONS*

Date: April 4, 1975

Type of Plant: Phosphate rock calciner

Type of Discharge: particulate

Location of Discharge: Stack from scrubber

Height of Point of Discharge: 105 feet

Description of Background: Sky

Description of Sky: Overcast

Wind Direction: North

Color of Plume: White

Interference of Steam Plume: Yes

Duration of Observation: 2 hours, 5 minutes

Distance from Observer to Discharge Point: 1440 feet

Height of Observation Point: Ground level

Direction of Observer from Discharge Point: South Southeast

Wind Velocity: 3-10

Detached Plume: No

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Average	Set Number	Time Start	Time End	Opacity Average
1	2:50	2:56	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

*Two observers made simultaneous readings. The greater of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-21, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

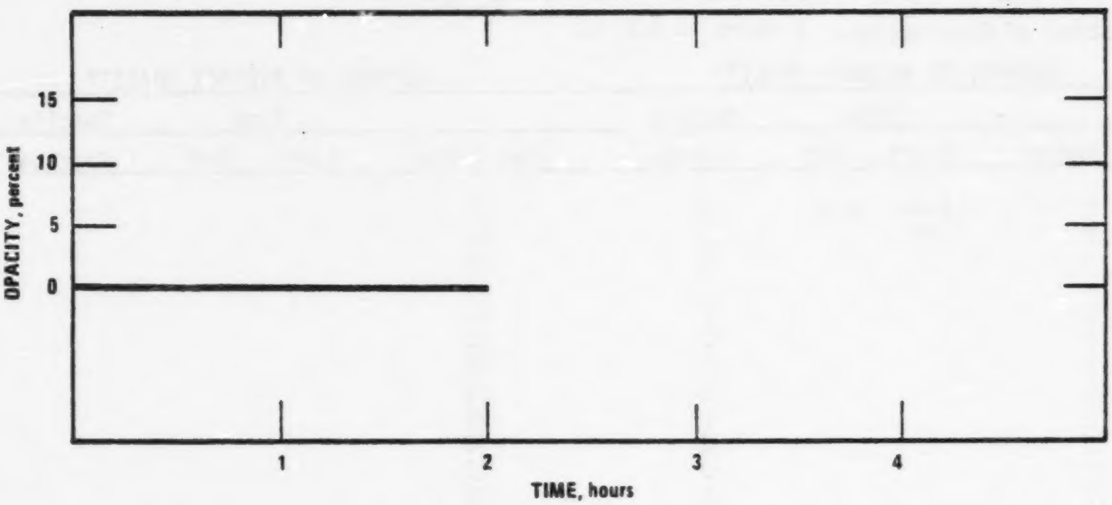

Table C-22
FACILITY C
SUMMARY OF VISIBLE EMISSIONS *

Date: April 5, 1975

Type of Plant: Phosphate rock calciner

Type of Discharge: Particulate

Distance from Observer to Discharge Point: 600 feet

Location of Discharge: Stack from scrubber

Height of Point of Discharge: 105 feet

Height of Observation Point: Ground level

Description of Background: Sky

Direction of Observer from Discharge Point: East

Description of Sky: Overcast

Wind Direction: South

Wind Velocity: 15-25

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: Yes

Duration of Observation: 2 hours, 5 minutes

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	8:45	9:01	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

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*Two observers made simultaneous readings. The greater of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-22, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

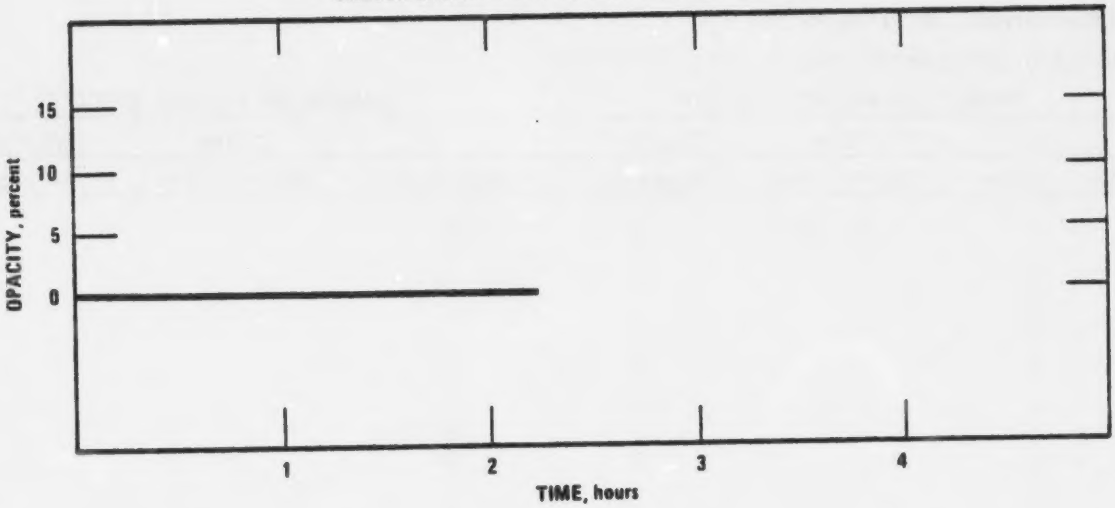


Table C-23
FACILITY C
SUMMARY OF VISIBLE EMISSIONS *

Date: April 9, 1975
Type of Plant: Phosphate rock calciner
Type of Discharge: particulate
Location of Discharge: Stack from scrubber
Height of Point of Discharge: 105 feet
Description of Background: Snowy sky
Description of Sky: Overcast
Wind Direction: South
Color of Plume: White
Interference of Steam Plume: Yes
Duration of Observation: 1 hour, 45 seconds

Distance from Observer to Discharge Point: 1/4 mile
Height of Observation Point: Ground level
Direction of Observer from Discharge Point: Southeast
Wind Velocity: 5-20
Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	8:50	8:56	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

*Two observers made simultaneous readings. The greater of their readings is reported.
**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-23, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

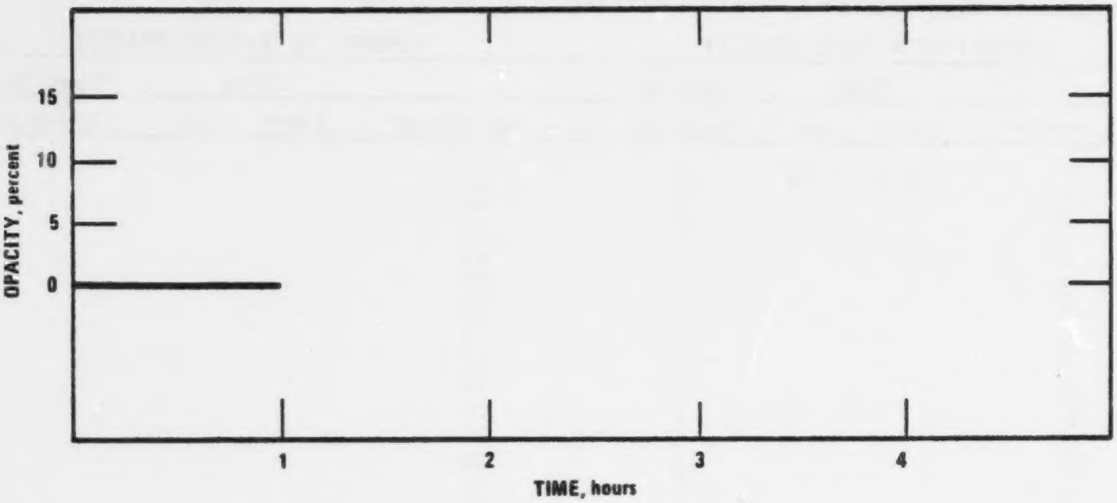


Table C-24

FACILITY C

SUMMARY OF VISIBLE EMISSIONS *

Date: April 9, 1975

Type of Plant: Phosphate rock calciner

Type of Discharge: Particulate

Distance from Observer to Discharge Point: 1440 feet

Location of Discharge: Stack from scrubber

Height of Point of Discharge: 105 feet

Height of Observation Point: Ground level

Description of Background: Sky

Direction of Observer from Discharge Point: Southeast

Description of Sky: Overcast

Wind Direction: South

Wind Velocity: 2-8

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: Yes

Duration of Observation: 2 hours, 0 minutes

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	5:00	5:06	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

*Two observers made simultaneous readings. The greater of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-24, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

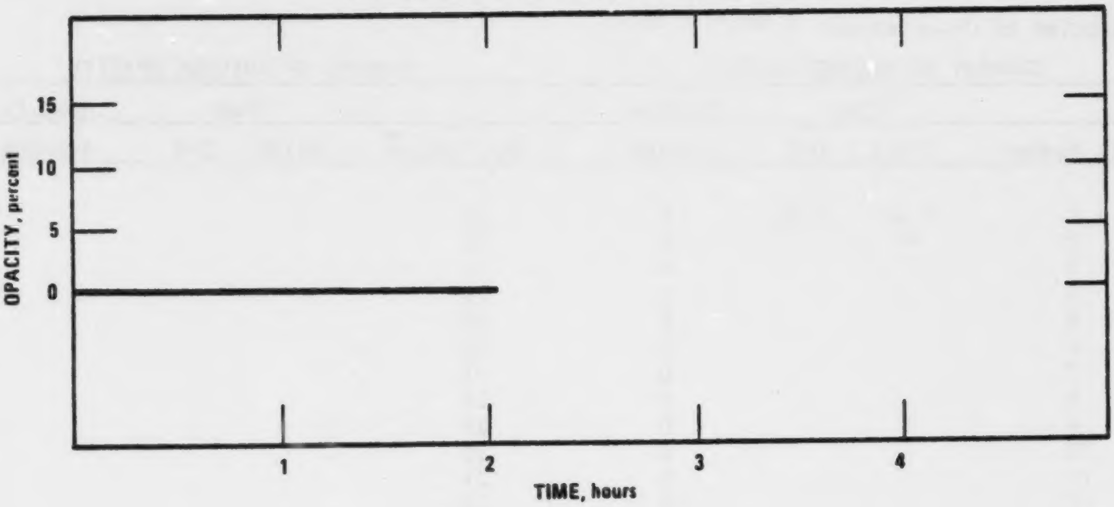


Table C-25

FACILITY C

SUMMARY OF VISIBLE EMISSIONS*

Date: April 10, 1975

Type of Plant: Phosphate Rock Calciner

Type of Discharge: Particulate

Distance from Observer to Discharge Point: 1440 feet

Location of Discharge: Stack from Scrubber

Height of Point of Discharge: 105 feet

Height of Observation Point: Ground Level

Description of Background: Sky

Direction of Observer from Discharge Point: Southeast

Description of Sky: Overcast

Wind Direction: East

Wind Velocity: 2 to 5

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: Yes

Duration of Observation: 2 hours 0 min

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Average	Set Number	Time Start	Time End	Opacity Average
1	7:30	7:36	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-25, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

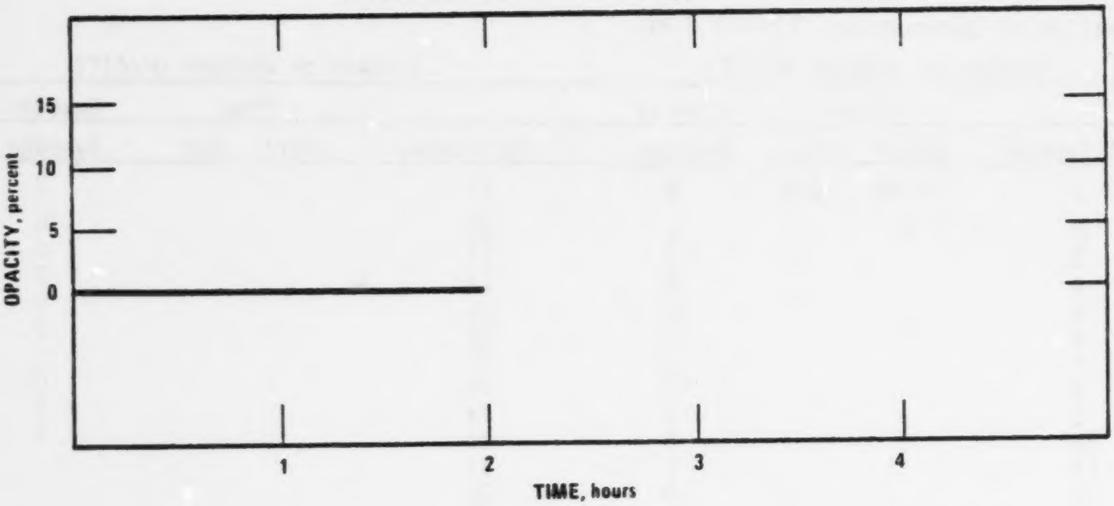


Table C-26
FACILITY C
SUMMARY OF VISIBLE EMISSIONS *

Date: April 10, 1975

Type of Plant: Phosphate Rock Calciner

Type of Discharge: Particulate

Location of Discharge: Stack from Scrubber

Height of Point of Discharge: 105 feet

Description of Background: Sky

Description of Sky: Overcast

Wind Direction: North

Color of Plume: White

Interference of Steam Plume: Yes

Duration of Observation: 3 hours 0 min

Distance from Observer to Discharge Point: 1400 feet

Height of Observation Point: Ground Level

Direction of Observer from Discharge Point: Southeast

Wind Velocity: 0 to 16

Detached Plume: No

SUMMARY OF AVERAGE OPACITY

	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	10:45	10:51	0	21			0
2	**		0	22			0
3			0	23			0
4			0	24			0
5			0	25			0
6			0	26			0
7			0	27			0
8			0	28			0
9			0	29			0
10			0	30			0
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-26, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

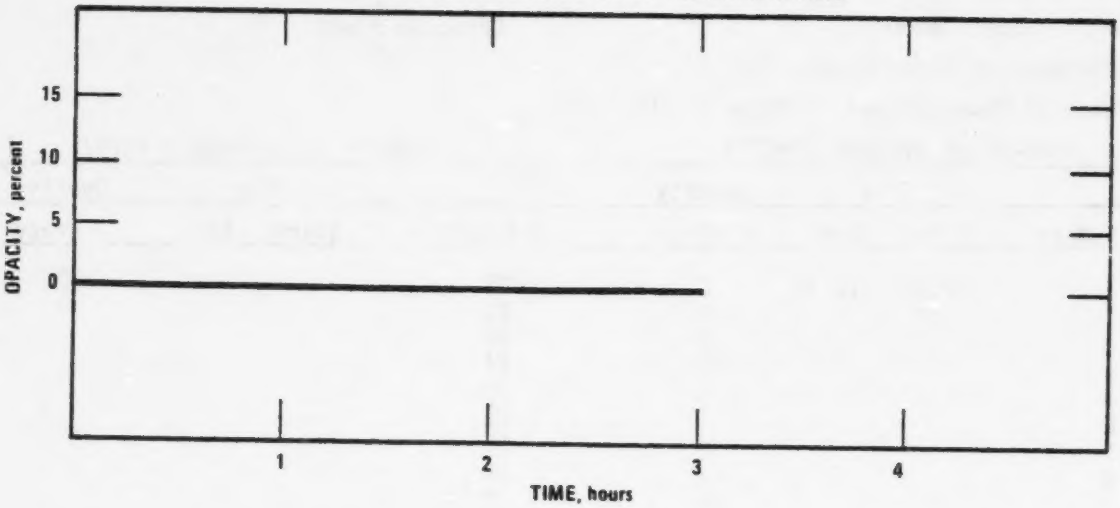


Table C-27
FACILITY F
SUMMARY OF VISIBLE EMISSIONS *

Date: March 25, 1975
Type of Plant: Phosphate Rock Grinder
Type of Discharge: Stack from Baghouse
Location of Discharge: Top of Stack
Height of Point of Discharge: 75 feet
Description of Background: Brown, Rusty Conveyor
Description of Sky: Overcast
Wind Direction: Not Reported
Color of Plume: White
Interference of Steam Plume: No
Duration of Observation: 2 hours 14 min

Distance from Observer to Discharge Point: 50 feet
Height of Observation Point: 85 feet
Direction of Observer from Discharge Point: East
Wind Velocity: Not Reported
Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	12:30	12:36	0	21			0
2	**		0	22			0
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-27, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

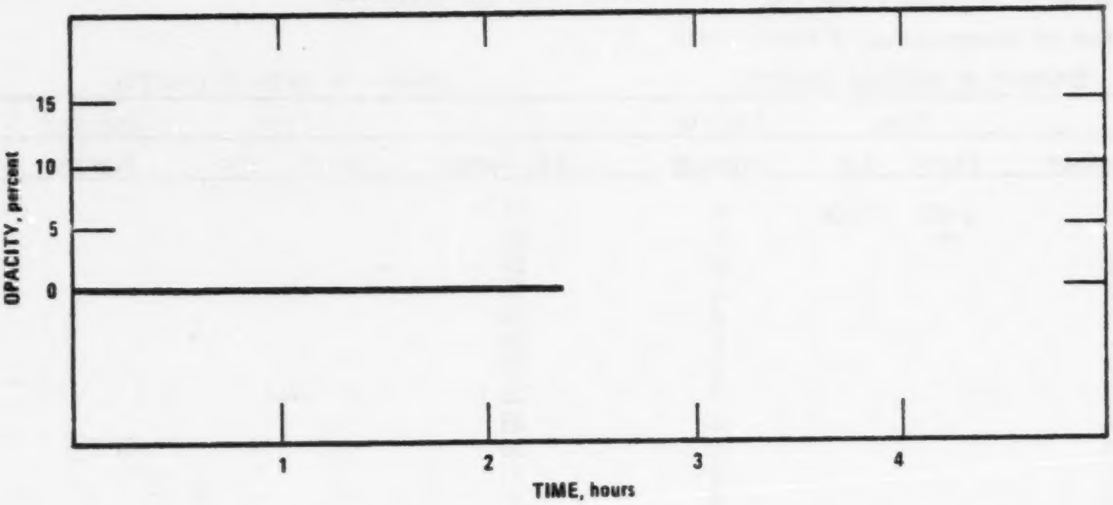


Table C-28

FACILITY F

SUMMARY OF VISIBLE EMISSIONS *

Date: March 25, 1975

Type of Plant: Phosphate Rock Grinder

Type of Discharge: Stack from Baghouse

Distance from Observer to Discharge Point: 50 feet

Location of Discharge: Top of Stack

Height of Point of Discharge: 75 feet

Height of Observation Point: 90 feet

Description of Background: Brown, Rusty Conveyor

Direction of Observer from Discharge Point: East

Description of Sky: Partly Cloudy

Wind Direction: Northwest

Wind Velocity: 10

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: No

Duration of Observation: 2 hours 0 min

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	5:00	5:06	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-28, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

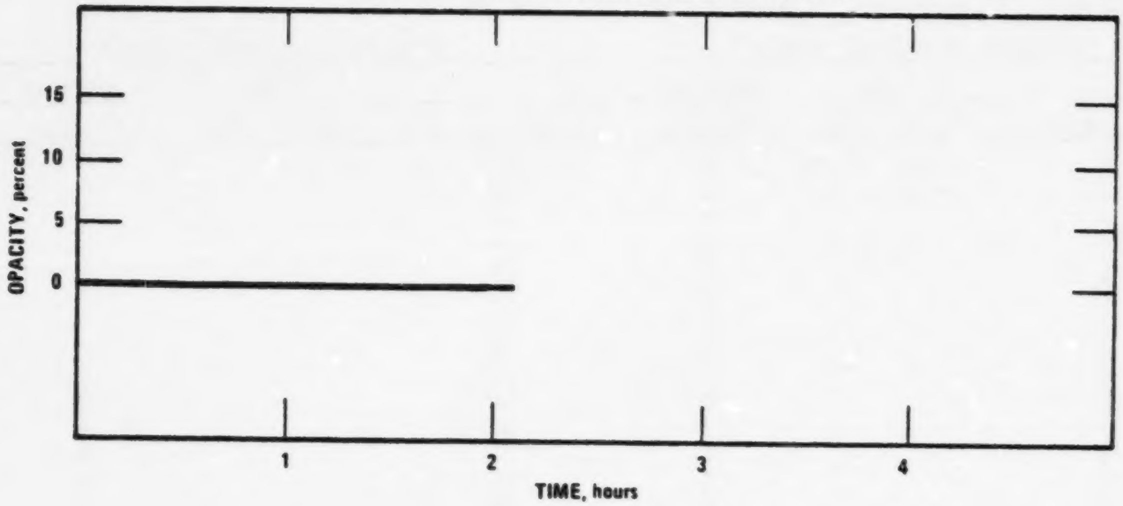


Table C-29

FACILITY F

SUMMARY OF VISIBLE EMISSIONS *

Date: March 26, 1975

Type of Plant: Phosphate Rock Grinder

Type of Discharge: Stack from Baghouse

Location of Discharge: Top of Stack

Height of Point of Discharge: 75 feet

Description of Background: Off-white Building

Description of Sky: Clear

Wind Direction: Northeast

Color of Plume: White

Interference of Steam Plume: No

Duration of Observation: 2 hours 0 min

Distance from Observer to Discharge Point: 50 feet

Height of Observation Point: 85 feet

Direction of Observer from Discharge Point: East

Wind Velocity: 15 to 25

Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	11:00	11:06	0	21			0
2	**		0	22			0
3			0	23			0
4			0	24			0
5			0	25			0
6			0	26			0
7			0	27			0
8			0	28			0
9			0	29			0
10			0	30			0
11			0	31			0
12			0	32			0
13			0	33			0
14			0	34			0
15			0	35			0
16			0	36			0
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-29, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

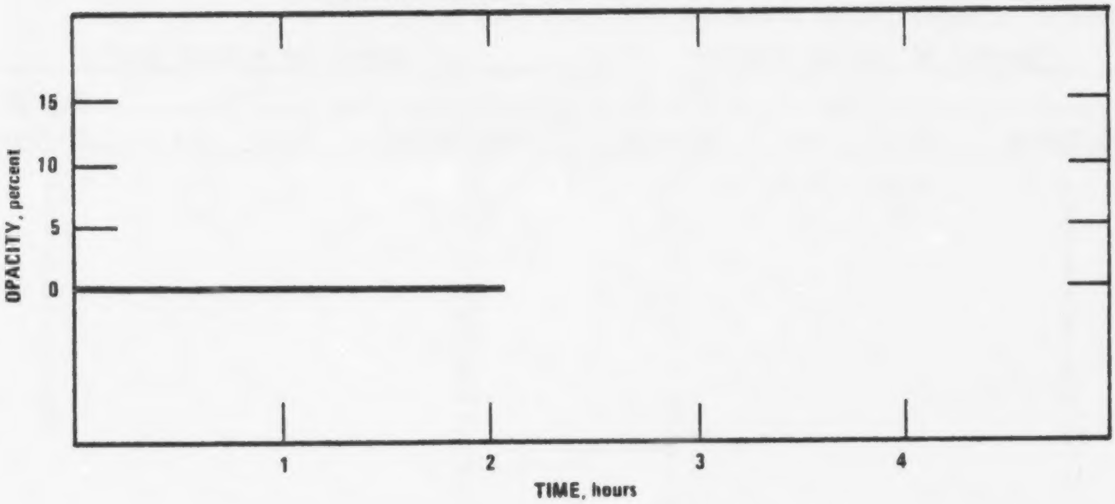


Table C-30

FACILITY G

SUMMARY OF VISIBLE EMISSIONS *

Date: April 5, 1975
Type of Plant: Phosphate Rock Grinder
Type of Discharge: Particulate
Location of Discharge: Duct from Baghouse
Height of Point of Discharge: 46 feet
Description of Background: Dark Building
Description of Sky: Overcast
Wind Direction: South
Color of Plume: None
Interference of Steam Plume: No
Duration of Observation: 3 hours 0 min

Distance from Observer to Discharge Point: 270 feet
Height of Observation Point: Ground Level
Direction of Observer from Discharge Point: East
Wind Velocity: 4 to 20
Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	4:00	4:06	0	21			0
2	**		0	22			0
3			0	23			0
4			0	24			0
5			0	25			0
6			0	26			0
7			0	27			0
8			0	28			0
9			0	29			0
10			0	30			0
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there was a 16 minute lapse (6:44 to 7:00) in readings during a plant malfunction.

Table C-30, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

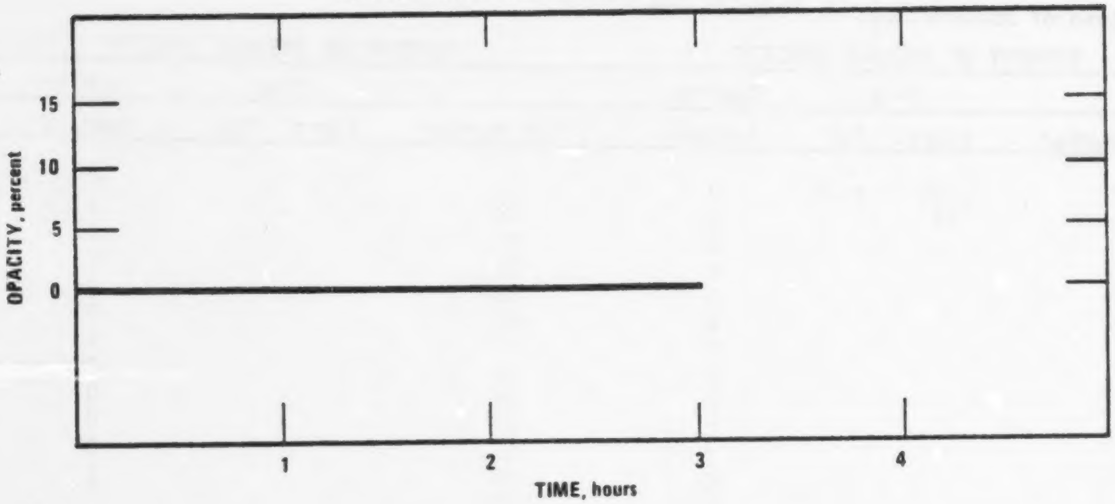


Table C-31

FACILITY G

SUMMARY OF VISIBLE EMISSIONS *

Date: April 7, 1975
Type of Plant: Phosphate Rock Grinder
Type of Discharge: Particulate
Location of Discharge: Duct from Baghouse
Height of Point of Discharge: 46 feet
Description of Background: Dark Building
Description of Sky: Overcast
Wind Direction: Northwest
Color of Plume: None
Interference of Steam Plume: No
Duration of Observation: 3 hours 20 min

Distance from Observer to Discharge Point: 270 feet
Height of Observation Point: Ground Level
Direction of Observer from Discharge Point: East
Wind Velocity: 7 to 15
Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	9:25	9:31	0	21			0
2	**		0	22			0
3			0	23			0
4			0	24			0
5			0	25			0
6			0	26			0
7			0	27			0
8			0	28			0
9			0	29			0
10			0	30			0
11			0	31			0
12			0	32			0
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-31, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

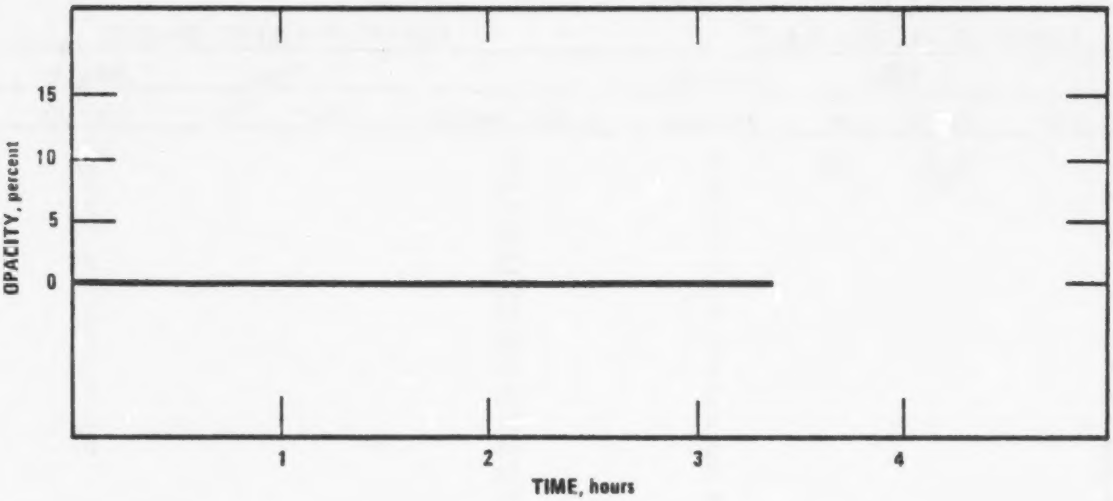


Table C-32
FACILITY 6
SUMMARY OF VISIBLE EMISSIONS *

Date: April 7, 1975

Type of Plant: Phosphate Rock Grinder

Type of Discharge: Particulate

Location of Discharge: Duct from Baghouse

Height of Point of Discharge: 46 feet

Description of Background: Dark Building

Description of Sky: Overcast

Wind Direction: Northwest

Color of Plume: None

Interference of Steam Plume: No

Duration of Observation: 3 hours 20 min

Distance from Observer to Discharge Point: 275 feet

Height of Observation Point: Ground Level

Direction of Observer from Discharge Point: Northeast

Wind Velocity: 5 to 13

Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	3:20	3:26	0	21			0
2	**		0	22			0
3			0	23			0
4			0	24			0
5			0	25			0
6			0	26			0
7			0	27			0
8			0	28			0
9			0	29			0
10			0	30			0
11			0	31			0
12			0	32			0
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings. The greater of their readings is reported.

** Subsequent sets were each of 6 minutes duration, and visible emissions measurements were curtailed for twenty minutes (from 5:51 to 6:11) during a plant malfunction.

Table C-32, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

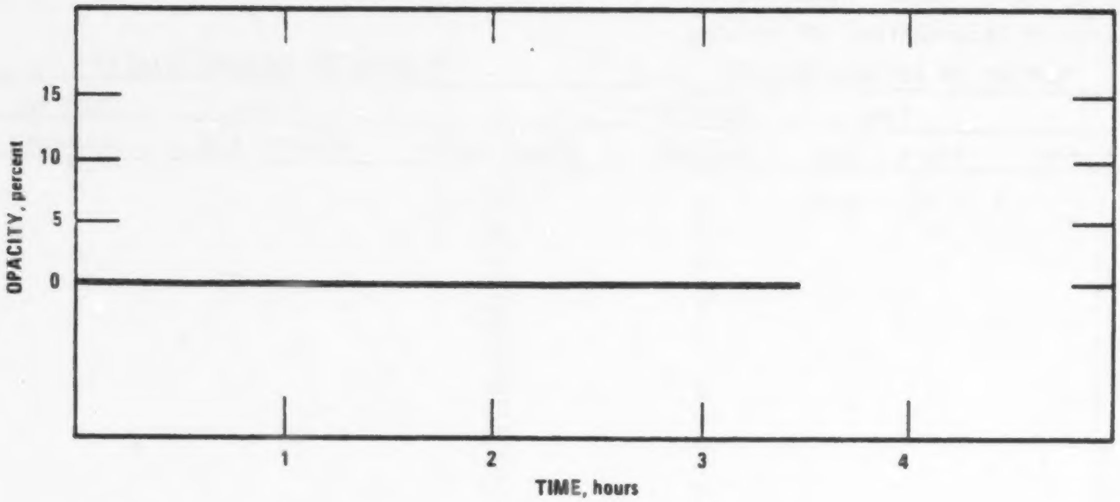


Table C-33

FACILITY H.

SUMMARY OF VISIBLE EMISSIONS *

Date: March 26, 1975
Type of Plant: Materials Handling
Type of Discharge: Particulate
Location of Discharge: Baghouse Stack
Height of Point of Discharge: 150 feet
Description of Background: Green Trees
Description of Sky: Clear
Wind Direction: Northeast
Color of Plume: White
Interference of Steam Plume: No
Duration of Observation: 120 minutes

Distance from Observer to Discharge Point: 75 feet
Height of Observation Point: 150 feet
Direction of Observer from Discharge Point: South-Southwest
Wind Velocity: 5
Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	3:00	3:06	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12			0	32			
13			0	33			
14			0	34			
15			0	35			
16			0	36			
17			0	37			
18			0	38			
19			0	39			
20			0	40			

* Two observers made simultaneous readings.

** Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-33, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

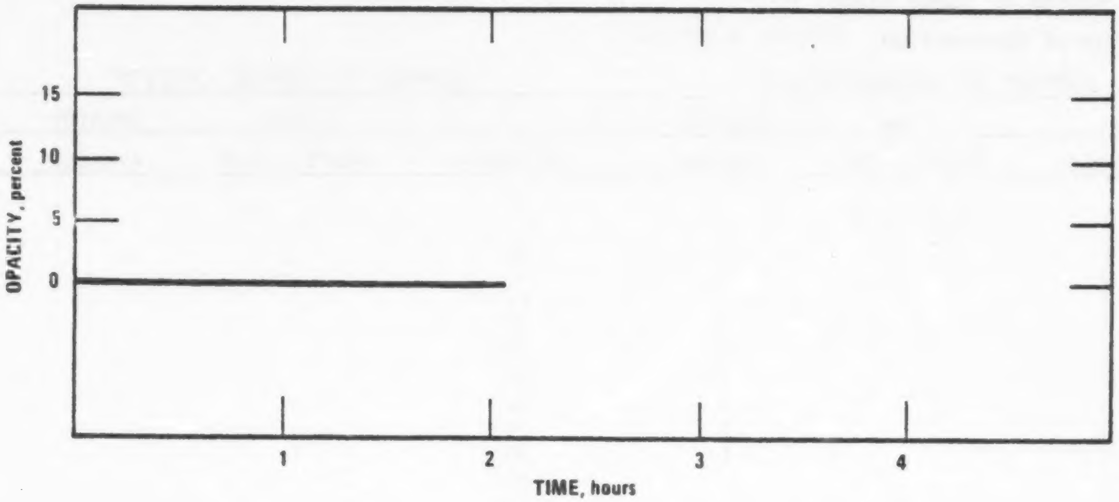


Table C-34

FACILITY I

SUMMARY OF VISIBLE EMISSIONS *

Date: March 25, 1975

Type of Plant: Ground rock transfer

Type of Discharge: Stack from baghouse

Distance from Observer to Discharge Point: 300 feet

Location of Discharge: Top of stack

Height of Point of Discharge: 100 feet

Height of Observation Point: 30 feet

Description of Background: Dark gray overcast sky

Direction of Observer from Discharge Point: North

Description of Sky: Overcast

Wind Direction: West

Wind Velocity: 10

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: No

Duration of Observation: 1 hour, 0 minutes

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Average	Set Number	Time Start	Time End	Opacity Average
1	3:17	3:23	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

*Two observers made simultaneous readings. The greater of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-34, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

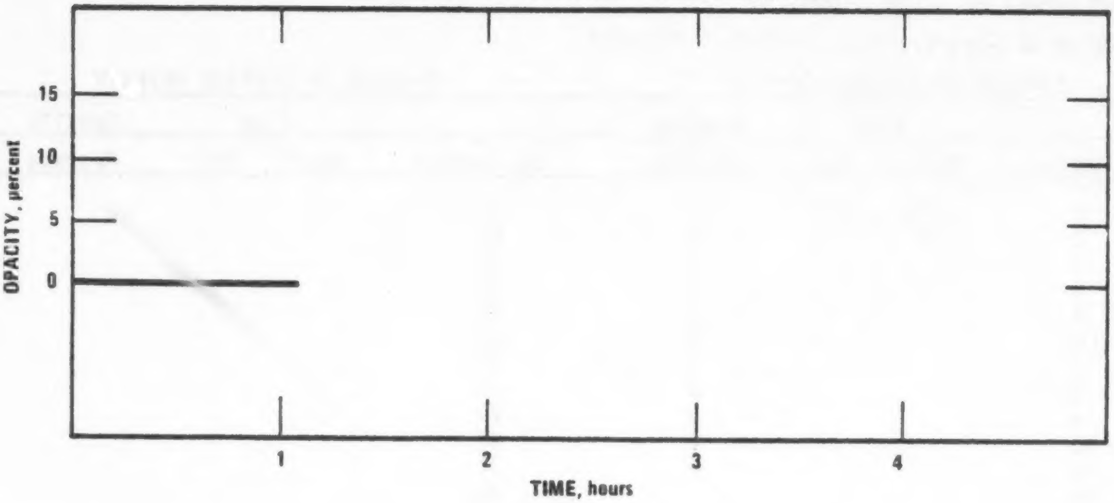


Table C-35

FACILITY J

SUMMARY OF VISIBLE EMISSIONS *

Date: March 25, 1975

Type of Plant: Ground rock transfer

Type of Discharge: Stack from baghouse

Location of Discharge: Top of stack

Height of Point of Discharge: 120 feet

Description of Background: Gray sky

Description of Sky: Overcast

Wind Direction: Northwest

Color of Plume: White

Interference of Steam Plume: No

Duration of Observation: 1 hour, 0 minutes

Distance from Observer to Discharge Point: 150 feet

Height of Observation Point: 75 feet

Direction of Observer from Discharge Point: Northwest

Wind Velocity: 10

Detached Plume: No

SUMMARY OF AVERAGE OPACITY				SUMMARY OF AVERAGE OPACITY			
	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	4:45	4:51	0	21			
2	**		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11			0	31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

*Two observers made simultaneous readings. The greater of their readings is reported.

**Subsequent sets were each of 6-minutes duration, and there were no time lapses between sets.

Table C-35, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:

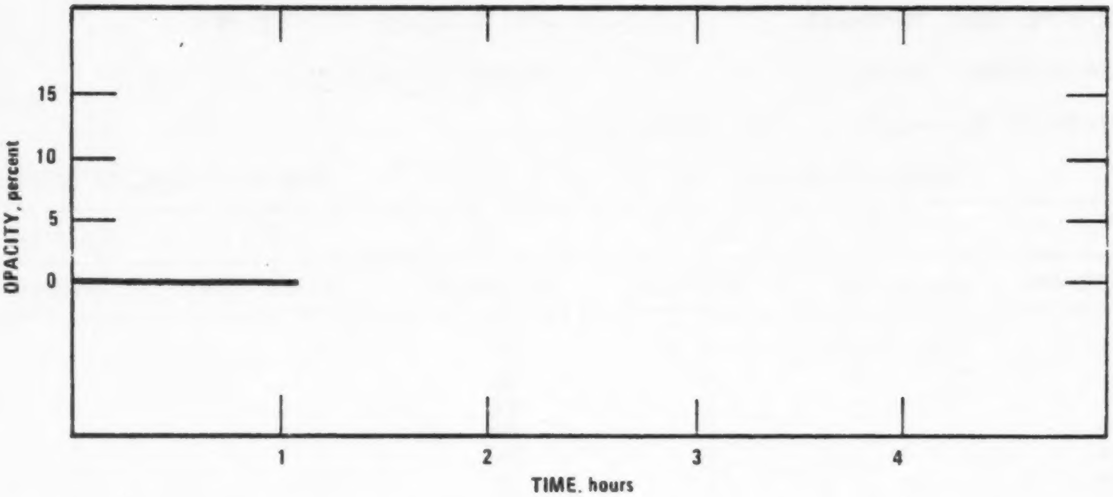


TABLE C-36
FACILITY K
Summary of Visible Emissions

Date: June 22, 1976

Type of Plant: Phosphate rock calciner

Type of Discharge: Stack from scrubber

Distance from Observer to Discharge Point: 200 yards

Location of Discharge: Top of stack

Height of Observation Point: Ground level

Height of Point of Discharge: 150 feet

Direction of Observer from Discharge Point: Northwest

Description of Background: Sky

Description of Sky: Partly cloudy

Wind Direction: Northeast

Wind Velocity: 15 - 20 MPH

Color of Plume: White

Detached Plume: Yes

Duration of Observation: 1 hour 0 minutes

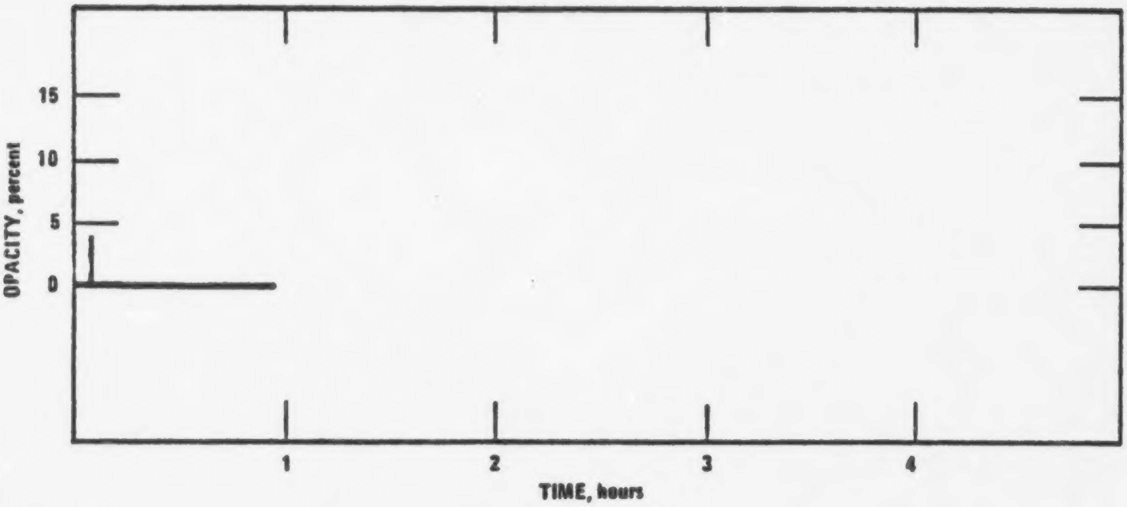
SUMMARY OF AVERAGE OPACITY

	Time		Opacity		Time		Opacity
Set Number	Start	End	Average	Set Number	Start	End	Average
1	2:00	2:06	0.83	21			
2	*		0	22			
3			0	23			
4			0	24			
5			0	25			
6			0	26			
7			0	27			
8			0	28			
9			0	29			
10			0	30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

* Subsequent sets were each of 6 minutes duration, and there were no time lapses between sets.

Table C-36, continued.

SKETCH SHOWING HOW OPACITY VARIED WITH TIME:



APPENDIX D. EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 Emission Measurement Methods

For the phosphate rock processing industry, the Environmental Protection Agency relied on Method 5 for measuring particulate emissions, Method 9 for measuring visible emissions, and Method 13B for fluoride emissions. These methods were used as described in Appendix A of 40 CFR Part 60 and published in the Federal Register (December 23, 1971 and October 23, 1974).

The particulate mass catches from these process emissions were relatively low, especially for the baghouse controlled emissions. The mass catch amounts ranged from about 12 mg to over 300 mg. For the particularly low concentrations, some tests were extended to over 3 hours in an effort to obtain accurately measurable catches. In-house tests have shown that acceptable accuracy (± 10%) can be obtained with a minimum catch of 25 mg. Most of the inaccuracy at this level and lower is found on the high side of the measurement; that is, somewhat more mass is measured than is actually collected.

Visible emission readings were made difficult because of high moisture content of scrubber exhausts from several of the processes. In most cases, opacity readings were made at the leading edge of the steam plume.

D.2 Continuous Monitoring

Effluent gas from the phosphate rock processes are not excessively hot (less than 121° C or 250°F), but can contain fluorides that may react with water to form acids that would etch glass materials. Glass lenses on opacity monitoring equipment should either be protected from fluoride deposits or replaced with material not subject to etching. Visible emission monitors are covered by EPA performance standards contained is Appendix B of 40 CFR Part 60 (Federal Register, September 11, 1974).

Equipment and installation costs are estimated to be $18,000 to $20,000 and annual operating costs, including data recording and reduction, are estimated at $8,000 to $9,000.

D.3 Performance Test Methods

The performance test method recommended for particulate matter is Method 5. Because of the construction of some control equipment, special stack extensions may be required to obtain acceptable sampling conditions. Low particulate concentrations in the stack gases from fabric collectors necessitate longer sampling times and larger sample volumes. The recommended minimum sampling volume is 4.5 dsm^3 (160 dscf). Commercially available high volume sampling trains conforming to Method 5 specifications would allow tests of shorter duration while obtaining the minimum sample volume, thus reducing time and expense of tests.

Sampling costs for a test consisting of 3 particulate runs is estimated to be about $5,000 to $9,000. This estimation is based on the sampling site modifications such as ports, scaffolding, ladders, and extensions costing from $2,000 to $4,000 and testing being conducted by contractors. If in-plant personnel are used to conduct the tests, the costs will be somewhat less.

Method 9 is recommended for visible emissions.

APPENDIX E. ENFORCEMENT ASPECTS

E.1. GENERAL

The recommended standards of performance will limit emissions of particulates and visible emissions from phosphate rock dryers, calciners, grinders and ground rock transfer systems at phosphate rock plants. The control systems which can be installed to comply with these standards are scrubbers, fabric filters, electrostatic precipitators, or a combination of these. The control system may serve one or several affected facilities simultaneously. Aspects of enforcing these standards are discussed below for each affected facility.

E.2. DRYERS

Factors affecting the level of uncontrolled emissions from phosphate rock dryers include the design and operation of the dryer and the type of rock being dried. The effect of process design and operation on uncontrolled emissions is discussed in Chapter 3. The operator usually has little control over the design of the dryer after it is installed, and operation during a compliance test should be no different than the way the process is normally operated. The compliance test should be performed while the dryer is operating at the maximum production rate at which it is expected to run in the future, which may be greater than design parameters indicate. As stated in the facility descriptions in Appendix C, dryers are designed for a certain degree of moisture removal, and production at this moisture removal rate will be a function of the characteristics of the feed to the dryer. Generally, production throughput at a constant moisture removal rate will be greater for small, dry feed than for large, wet feed. The enforcement official should therefore be more concerned with the heat input (fuel addition rate) to the dryer than the production throughput. Some dryers are designed to burn more than one type of fuel (i.e., natural gas or fuel oil). In these cases, emissions from the dryer should be sampled while the dryer is burning the dirtiest fuel it will burn in the future. An exception to this would occur if the dryer is designed to burn one fuel, such as natural gas, during normal operation, but can use an alternate fuel, such as fuel oil, when the cleaner fuel is not available. In these cases, the dryer should be tested during normal conditions (e.g., burning natural gas). What is "normal" is somewhat subjective and should be determined by the enforcing agency.

The type of rock being processed by the dryer may affect emissions from some dryers processing rock from the Florida deposits. The Florida rock falls into two calssifications, pebble rock and concentrates. Most operators indicate that they experience greater particulate emissions when drying pebble rock than when drying concentrates. The reason they give is that the pebble rock goes through fewer washings in the beneficiation process (see Chapter 3) and, therefore, has more clay adhering to its surface. Attrition in the dryer causes submicron-sized clay particles to be sloughed off, resulting in greater emissions to the control system. Because of this, at least half of the rock being processed during the performance tests should be pebble rock. Of course, if pebble rock will never be processed in the dryer, this requirement should be waived.

E.3. CALCINERS

The enforcement aspects for calciners are the same as those presented above for dryers. The only noteworthy difference is that it is unlikely that any units will be built to calcine Florida rock, so the type of raw material fed to the calciner need not concern the enforcement official.

E.4. GRINDERS

Phosphate rock grinders are of two basic designs: ball mills and roller mills. Ball mills are usually ducted to a single control device; however, roller mills are frequently operated in parallel with several ducted to one control device. Therefore, it is incumbent on the enforcement official to be certain that all mills ducted to the control device are operating during the compliance tests. Types of raw materials do not affect emissions from phosphate rock grinders.

Factors which affect production rate from phosphate rock grinders are the mesh size (fineness) of the grind and the design of the grinder. Generally, emissions per ton of production will increase as the rock is ground to smaller mesh sizes. To increase the fineness of the grind, the operator must increase the residence time of the rock in the grinder, biasing the particle size distribution toward the smaller sizes. However, the process which will ultimately use the ground rock has been designed to accept a certain size rock, typically 60 percent through 200 mesh, and operates most efficiently with that size of rock. Therefore, fineness of the grind is not generally a parameter which the operator changes frequently. As with dryers and calciners, production throughput of grinders is incidental to other considerations. Production tonnage decreases as the mesh size being produced gets smaller. Once the product size is set, the operator usually monitors the amperage of the mill motor and/or mill fan and runs the grinding mill at the maximum production possible without damaging the equipment. The enforcement official should obtain these maximum tolerances from previous operating data (usually available from past log sheets) or, if necessary, from design data.

E.5. GROUND ROCK HANDLING SYSTEMS

The ground rock handling standard is unique in that it only regulates visible emissions. Also, because the ground rock handling system usually operates intermittently, the visible emissions test must be scheduled when the system will be operated for the duration of the observations.

APPENDIX F. THE STACK GAS DISPERSION MODEL

F.1. DESCRIPTION OF THE SINGLE SOURCE MODEL (JMHCRD-1)

The model used to estimate ambient concentrations for the phosphate rock processing plant is one developed by the Meteorology Laboratory, EPA. This model is designed to estimate concentrations due to sources at a single location for averaging times from one hour to one year.

This model is a Gaussian plume model using diffusion coefficients suggested by Turner (1970).* Concentrations are calculated for each hour of the year, from observations of wind direction (in increments of 10 degrees), wind speed, mixing height, and atmospheric stability. The atmospheric stability is derived by the Pasquill classification method as described by Turner (1970). In the application of this model, all pollutants are considered to display the dispersion behaviour of non-reactive gases.

Meteorological data for 1964 are used as input to the model. The reasons for this choice are: (1) data from earlier years did not have sufficient resolution in the wind direction; and (2) data from subsequent years are readily available on magnetic tape only for every third hour.

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*Turner, D. B., "Workbook of Atmospheric Dispersion Estimates," U.S. Dept. of H.E.W., PHS Publication No. 999-Ap-24 (Revised 1970).

Mixing height data are obtained from the twice-a-day upper air observations made at the most representative upper air station. Hourly mixing heights are estimated by the model using an objective interpolation scheme.

A feature of this model is the modification of plume behavior to account for aerodynamic effects for plants in which the design is not optimal (see Appendix B). Another important aspect of the model is the ability to add concentrations from stacks located closely together. In this feature, no consideration is given to the physical separation between the stacks since all are assumed to be located at the same geographical point.

Calculations are made for 180 receptors (at 36 azimuths and five selectable distances from the source). The JMHCRD-1 model used here can consider both diurnal and seasonal variations in the source. Separate variation factors can be applied on a monthly basis to account for seasonal fluctuations and on an hourly basis to account for diurnal variations. Another feature of the model is the ability to compute frequency distributions for concentrations of any averaging period over the course of a year. Percentages of various ranges in pollutant concentrations are calculated.

F.2. AERODYNAMIC-EFFECTS MODIFICATION OF THE SINGLE SOURCE MODEL

Note: The aerodynamic-effects version is a more general form of the single source model. All remarks made in section F.1 apply equally to either version.

The single source model does not address the aerodynamic complications which arise when plant design is less than ideal. These effects result from the interaction of the wind with the physical structure of the plant. Such interaction can retard or, in the extreme, prevent plume rise. The extreme case is commonly referred to as "downwash." With downwash, the effluent is brought downward into the wake of the plant, from which point it diffuses as though emitted very close to the ground. In the retardation case, some of the dispersive benefits of plume rise are lost; while in the downwash case, all of the benefits of plume rise are lost, along with most of the benefits of stack elevation. Both phenomena--but especially downwash--can seriously increase the resulting ambient air impact.

The aerodynamic-effects modification, then, is an attempt to include these effects in a predictive model. It was developed within EPA and, while not yet validated, is the best-known operational approach. Basically, it enables the model to make an hour-by-hour, stack-by-stack assessment of the extent (if any) of aerodynamic complications. The parameters used in making the assessment are wind speed, stack gas exit velocity, stack height, stack diameter, and building height. If a particular assessment indicates no aerodynamic effect, then for that stack for that hour, the model behaves just like the unmodified version. If there are aerodynamic effects, the modified version contains equations by which the impact of these effects on ground-level concentrations is estimated.

APPENDIX G. CONVERSION FROM ENGLISH TO METRIC UNITS

To convert from	to	Multiply by
Acre (ac)	Square Meter (m^2)	4.047×10^3
British Thermal Unit (Btu)	Joule (J)	1.055×10^3
Cubic Foot (ft^3)	Cubic Meter (m^3)	2.832×10^{-2}
Degree Farenheit (°F)	Degree Celsius (°C)	°C = (°F - 32)/1.8
Gallon (G)	Cubic Meter (m^3)	3.785×10^{-3}
Grains per Actual Cubic Foot (Gr/ACF)	Milligrams per Actual Cubic Meter (mg/m^3)	2.288×10^3
Grains per Dry Standard Cubic Foot (gr/dscf)	Milligrams per Dry Standard Cubic Meter (mg/dsm^3)	2.288×10^3
Inch of Water (Pressure)	Pascal (Pa)	2.488×10^2
Pound (lb)	Kilogram	4.536×10^{-1}
Square Foot (ft^2)	Square Meter (m^2)	9.290×10^{-2}
Ton (T)	Kilogram (kg)	9.072×10^2
Ton per Hour (TPH)	Kilogram per Second (kg/s)	2.520×10^{-1}